Docket No.: 0717-0525PUS1
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Satoshi OKADA

Application No.: 10/505,406 Confirmation No.: 8973

Filed: March 28, 2005 Art Unit: 2628

For: CHARACTER DISPLAY APPARATUS AND CHARACTER DISPLAY METHOD, CONTROL PROGRAM FOR CONTROLLING THE CHARACTER DISPLAY METHOD AND RECORD MEDIUM RECORDING THE CONTROL PROGRAM

Examiner: J. B. Amin

DECLARATION UNDER 37 CFR §1.131

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

I, Satoshi Okada, hereby declare that:

1. I am the Inventor of the invention disclosed and claimed in the United States Patent Application No. 10/505,406.

2. I am aware of the prosecution history of United States Patent Application No. 10/505,406, which was filed in the U.S. Patent and Trademark Office on March 28, 2005, based upon International Application PCT/JP03/01818 filed in Japan on February 19, 2003, and that a claim of Priority of Application No. 2002-48258, filed in Japan on

February 25, 2002 was claimed under 35 USC § 119 in United States Patent Application No. 10/505,406.

3. The subject matter of United States Patent Application No. 10/505,406 is included in Application No. 2002-48258, filed in Japan on February 25, 2002.

4. To my knowledge, and in view of the factual evidence supplied herewith, the present invention was conceived in Japan prior to January 9, 2002, the filing date of U.S. Patent No. 7,006,096. This fact is evidenced by the attached copy of a PROPOSAL OF AN INVENTION (an English translation of which is attached also) which I prepared as to Japanese Application No. 2002-48258, and the attached translation of Japanese Application No. 2002-48258. The copy of the PROPOSAL OF AN INVENTION includes the following:

(i) A cover sheet including a preparation date which is prior to January 9, 2002; Title of the invention: Character Display Apparatus, Character Display Method, Recording Medium, and Program; reference No. of 01J04534; Names of Inventor: OKADA, Satoshi; A short summary; A stamp by IP section showing it was received on a date which is prior to January 9, 2002; A stamp by KOTANI, Akio who is a chief of the inventor's section; (A stamp by NISHITANI, Motohide, who is a person in charge of the IP section of SHARP KABUSHIKI KAISHA).

(ii) An assignment executed by the Inventor showing a date which is prior to January 9, 2002.

(iii) The specification draft, the first page thereof showing the reference No. of 01J04534.

(iv) Thirteen (13) sheets of drawings including Figs. 1-13.

5. I declare that all the above identified acts were carried out in Japan, a WTO member country.

6. I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful statement may jeopardize the validity of the application or any patent issuing thereon.

Date

Satoshi Okada

SHARP 特許/実用新案 出願依頼書 **極秘**

知的財産権本部	(技本) 特許開発室			依頼部門		
受付 SHARP [redacted] 受付	室長 [redacted]	IPクリエータ [redacted]	特許推進 /	チーフ	特許戦略委員	所属長

整理No.	特・実登
出願日	平成 年 月 日
受理No.	01104534
依頼No.	NR01614
特許推進室コード	C3

岡田 ·特許委員

依頼部門：技術本部 研究所名：システム開発センター (内線No. 8-741-3459)
テーマ名：インターF開発PT (所属コード：109400) 作成日： 平成[redacted]年[redacted]月[redacted]日

Executed Assignment

発明・考案者記入欄

本件について、特許・実用新案登録・意匠登録を受ける権利をシャープ株式会社に譲渡いたします。

(氏名コード) 発明・考案者		
1	フリガナ オカダ サトシ (S117738) 岡田哲 ㊞	4 フリガナ ( ) ㊞
2	フリガナ ( ) ㊞	5 フリガナ ( ) ㊞
3	フリガナ ( ) ㊞	6 フリガナ ( ) ㊞

発明・考案の名称：文字表示装置、文字表示方法、記録媒体およびプログラム (IPC G09G)

発明・考案の要旨：カラー表示デバイスのサブピクセルを使った文字表示において、注目するピクセルに隣接するサブピクセルに含まれる文字の基本部分の配列パターンに基づき、画素値テーブルを通して輝度レベルを決定することにより、処理が簡略になると共に、字形の補正を行うことが容易になる。

共同出願：相手先： 共同出願確認書に代表者名、相手方住所、発明（考案）者名・住所等をフリガナ付で記載し添付願います

所属長記入欄

―技術的価値―
a. 機能的効果 大 中 小
b. 発明のタイプ 基本発明 改良・周辺技術 防衛
(関連出願：99J03805号)
c. 公知技術との差異 有 いくらか有/不明 あまりない
(公知文献名：特開2001-100725、特開2001-184051)
公知技術事前調査
(調査手段) ・STEPS・STAGE・本部DB
・社外DB ( ) ・公報（公開・公告）
検索式／分類：別紙調査表に記載の通り
調査期間：1993年1月1日～2000年8月21日
d. 他社に対する影響力 強い 普通 弱い

(発明の評価に必要ですので全項目をなく正確に記入してください)

―経済的価値―
イ. コストダウン 大いに有 有 無 評価不能
ロ. 他社との差別化 大いに有 有 いくらか有
(セールスポイント等)
ハ. 市場規模 大 中 小
(具体的理由：カラー液晶ディスプレイ搭載商品全般に応用可)
ニ. 技術・製品の寿命 3年以上 不明 3年未満

Ⅰ. 実施化の見込み 採用決定 採用検討中 採用未定 著作の※
商品化計画：2001/12/Eまでに動展ぞろう
機種名：未定
Ⅱ. テーマの重要度 最重要 重要 普通
(商品戦略等) テーマ名：シームレスLCフォント

(記入時の留意事項) 1.「公知技術との差異」の項目の「公知文献名」は本発明に最も類似していると思われる公知技術について記載し、文献の写しを添付ください。
2.「市場規模」の項目は、数年後の市場予測を加味してください。
3.「実施化の見込み」の項目は、評価実験中又は工業会等において提案中のものであれば採用検討中と記載ください

依頼部門意見

外国出願予定 有 ・ 未定 ・ 無
(出願希望国：US, EPC, CH, KR)
(理由：)
外国出願される場合は、別途外国出願依頼書を提出願います。

特許提案会等からの提案： YES・NO
提案整理番号： 開催日：平成 年 月 日
開発テーマ テーマ名：

国内優先権の基礎出願 ：特・実登
社外発表等の公表予定日 平成 年 月 日 (製品・学会・他)

商品化された技術を強化する出願として重要のため、先行出願と同じ特許事務所での処理をお願いします。
(印)

□IP1 (先取り発明の育成)
□IP2 (核となる発明の充実・強化)
□IP3 (緊急案件の出願依頼書の作)
(担当者・氏名コード：

知財本部記入欄

発明の評価制度に基づき、本件は下記の結果となりましたので通知します。
A. 重点処理 Ⓑ 通常処理 C. 簡易処理（出願・公開技報）
D. 差戻し（記載不備、3週間以内に補充がなければ出願取りやめとします）
E. 出願取り止め

※開発室から補充資料受理済

所属長 [redacted] [redacted]

出願担当者 (氏名コード)	榎本 (034342)
特許事務所	山本 P.O.

[redacted]月度 ①

SHARP Patent Utility model Application request form

Confidential

Intellectual property rights headquarters	(Engineering headquarters) Patent development section			Request division			
Receipt	Section head	IP creator	Patent promotion	Chief	Patent strategy committee	group head	
SHARP Reception	MASUZAWA	SMOD		TOTANI	KONYA	KOTANI	

Ref. No	Peten/Utility Model Ref. No
Filing date	
Receipt No	01J04534
Request No	NR01614
Patent promotion section code	C3

OKADA :Patent committee

Request division: Engineering headquarters
Research laboratory name: System development center (Extension No. 8-741-3459)
Theme name: Inter F development PT (Group code: 109400)
Creation date

Space to be filled out by inventor(s)

I (we) assign the right for patent/utility model registration/design registration for the present case to SHARP KABUSHIKI KAISHA.

(Neme code) Inventor(s)

1	furigana okeda setoshi (S117738) OKADA SATOSHI	OKADA SS
2	furigana ( )	sign
3	furigana ( )	sign
4	furigana ( )	sign
5	furigana ( )	sign
6	furigana ( )	sign

Title of the invention: CHARACTER DISPLAY APPARATUS, CHARACTER DISPLAY METHOD, RECORDING MEDIEM AND PROGRAM

Summary of the invention: In a character display using sub-pixels of a color display device, a luminance level is determined via a pixel value table based on an arrangement pattern of a basic portion of a character included in a sub-pixels neighboring a pixel of interest. As a result, the process becomes simplified and a character can be easily corrected.

Co-application: Co-applicant:
Please write down on the co-application conformation form and attach thereto the name of the representative, the address of the co-applicant, the name(s) of the inventor(s)/address(s) etc together with furigana.

Space to be filled out by the group head (Please complete every item with accuracy and without omission since it is necessary to evaluate the invention)

—Technical value—

a. Functional affect: Large · Medium · Small

b. Type of the invention: Basic invention · Improvement/peripheral technique · Protection

(Related application(s): 99J03805 etc)

c. Diffrence with publicly-known technique(s): Yes · some/unknown · not-so-much

(Name(s) of the publicly-known reference(s)): Japan Laid-open Publication No. 2001-100725; Japan Laid-open Publication No. 2001-184051

Preliminary survey of the publicly-known technique(s)

(Survey means · ~~STEPS~~ · STAGE · ~~Headquarters DB~~ · ~~Outside DB (-)~~ · Gazetta · ~~(Publication of unexamined applications· Publication of examined applications)~~)

Search formula/category: As described in the attached survey sheet

Survey period: January 1, 1993 to August 21, 2000

d. Influence on other companies: Strong · Medium · Weak

—Economic value—

f. Cost-reduction: Great · Yes · No · Impossible to evaluate

g. Differentiation with other companies: Great · Yes · Some

(Selling point and the like)

h. Market size: Large · Medium · Small

(Specific reason: applicable to entire products mounted with color liquid crystal displays)

i. Lifetime of technique /product: More or 3 years · Unknown · Less than 3 years

j. Probability of implementation: Adoption decided · Adoption under study · Adoption undecided · Idea only

Commercialization plan: Filing of the application is completed by the end of December, 2001

Model name: Undecided

k. Importance of the theme: Most important · Important · Medium

(Merchandise strategy and the like)

Theme name: Seamless LC font

<Points to consider at the time of filing-out>
1. In "Name(s) of the publicly-known reference(s)" in the item "Difference with publicly-known technique(s)", please write down the publicly-known technique, which is most similar to the invention and attach a copy thereof.
2. In the item "Market size", please consider the market forecast in the coming years.
3. In the item "Probability of implementation", please write down as adoption under study if it is being under an evaluation experiment or being proposed at an industrial association.

Opinion from request division

Plan for foreign application(s): ~~Yes~~ · Undecided · No
(Countries to be desired for filing: US, EPC, CH, KR)
(Reason:
When foreign applications are filed, please separately submit the foreign application request form.

Basic application for the internal priority: (Reference No. of patent/utility model)

Since it is important to enforce the commercialized technique, please arrange with the same patent office which handled the previous application.

BS

Proposition by paten proposition committee and the like: ~~YES~~ · NO
Proposition reference number: Holding date
Development theme: Theme name: Seamless LC font

Planned date for publishing at outside presentation (Product/academic meeting/others)

☐ IP1 (Fostering of preampt invention)
☐ IP2 (Enrichment/enforcement of invention which becomes central)
☐ IP3 (Creation of application request form for an urgent case)

(Person in charge/name code:

Space to be filled out by the intellectual property department

We inform that the present invention has obtained the following results based on the evaluation system of invention. (application· Publication of examined applications)

A. Careful handing (B.) Routine handing C. Simplified handling
D. Remand (Improper description, if there is no complement within three weeks, the filing of the application will be withdrawn)
E. Withdrawal of the filing of the application

group head: Patent NISHITANI
Patent MAEYAMA

Person in charge of filing the application (Name code): ENOMOTO (034342) ENOMOTO

Patent office: YAMAMOTO P.O.

* Already received complementary material from the development section

CERTIFICATE OF TRANSLATION

I, TAKESHI OSHIO, patent attorney of Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-ku, Osaka 540-6015, Japan HEREBY CERTIFY that I am acquainted with the English and Japanese languages and that the attached English translation is a true English translation of what it purports to be, a translation of Japanese Patent Application No. 2002-48258 filed on 25 February, 2002 in the name of SHARP KABUSHIKI KAISHA.

Dated this 18th day of July 2007

Takeshi Oshio

TAKESHI OSHIO

(Translation)

[Name of the Document]	Application for Patent
[Reference No.]	01J04543
[Filing Date]	25 February, 2002
[Addressee]	To the Commissioner of the Patent Office
[IPC]	G09G 5/24
[Inventor]	
[Address]	c/o SHARP KABUSHIKI KAISHA 22-22, Nagaikecho, Abeno-ku, Osaka-shi, Osaka
[Name]	Satoshi OKADA
[Applicant for Patent]	
[Identification No.]	000005049
[Name]	SHARP KABUSHIKI KAISHA
[Agent]	
[Identification No.]	100078282
[Patent Attorney]	
[Name]	Shusaku YAMAMOTO
[Official Fee]	
[Account No.]	001878
[Amount]	21,000 yen

[List of the Documents]

[Item]	Specification	1
[Item]	Drawings	1
[Item]	Abstract	1

[General Power of Attorney No.]	9005652
[Proof]	Required

(Translation)

[Name of the Document] SPECIFICATION

[Title of the Invention] CHARACTER DISPLAY APPARATUS AND CHARACTER DISPLAY METHOD, CONTROL PROGRAM FOR CONTROLLING THE CHARACTER DISPLAY METHOD AND RECORDING MEDIUM RECORDING THE CONTROL PROGRAM

[Scope of the Claims]

[Claim 1] A character display apparatus, comprising

a display section having a character displayed thereon; and

a control section for controlling the display section,

wherein

a display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements is assigned to each sub-pixel,

the control section determines, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character, extracts an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels, and determines luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 2] A character display apparatus according to claim 1, wherein the control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when a position of the sub-pixel corresponding to the basic portion is replaced with a position of its neighboring pixel.

[Claim 3] A character display apparatus according to claim 1, wherein the control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when, in addition to the sub-pixel corresponding to the basic portion, its neighboring sub-pixel is duplicated as the basic portion.

[Claim 4] A character display apparatus according to claim 1, wherein the control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to a combination of a character color and a background color to be displayed.

[Claim 5] A character display apparatus according to claim 1, wherein the control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to the size of the difference between character and background colors previously registered and character and background colors to be displayed.

[Claim 6] In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a method for displaying a character on a display surface of the display section, comprising the steps of:

determining, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extracting an arrangement of sub-pixels

corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determining luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 7] In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a control program used when a character is displayed on a display surface of the display section, having a procedure described thereon for causing the control section to:

determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Claim 8] A recording medium readable by a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, the recording medium including a control program recorded thereon having a procedure described thereon for

causing the control section to:

determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character;

extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and

determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to: a character display apparatus, including a display section capable of displaying color, capable of displaying characters with high resolution; a character display method; a control program for controlling the character display method; and a recording medium having the control program recorded thereon.

[0002]

[Prior Art]

Some personal computers, word processors, mobile telephones and the like include a display section capable of displaying color. As a technique for displaying characters with high resolution in such apparatuses, for example, Japanese Laid-Open Publication No. 2001-100725 discloses the following character display apparatus.

[0003]

This character display apparatus is provided with a plurality of pixels on a display surface of the display apparatus. Each pixel includes a plurality of sub-pixels arranged in a predetermined direction, to which a respective color

element (e.g., Red (R), Green (G), and Blue (B)) is assigned. The strength of a color element in a sub-pixel is represented by the level of the color element set in a plurality of steps, e.g., 0 to 7. If a certain level of color element is assigned to a sub-pixel corresponding to the skeleton of a character, color element levels which vary stepwise around the sub-pixel are assigned to its surrounding sub-pixels. The color element levels are set in a predetermined pattern. Each color element level is converted to a luminance level based on a predetermined correspondence.

[0004]

The level of a color element corresponds to the degree of the color element which contributes to the color of a character. Therefore, the greater the contribution of a sub-pixel to the color of a character, the greater the color element level of the sub-pixel. The greater the contribution of a sub-pixel to the color of a background, the lower the color element level of the sub-pixel. In addition, the luminance level of a sub-pixel corresponds to the degree of light emission of the sub-pixel. The greater the luminance level of a sub-pixel, the greater the degree of light emission of the sub-pixel. The lower the luminance level, the lower the degree of light emission. Thus, by controlling the color element level on a sub-pixel-by-sub-pixel basis so as to represent the shapes of characters, the characters can be displayed with higher resolution than when the luminance level is controlled on a pixel-by-pixel basis. Further, by forming a pattern of color element levels which vary stepwise around a sub-pixel corresponding to the skeleton of a character, color noise can be suppressed.

[0005]

Further, Japanese Laid-Open Publication No. 2001-184051 discloses another character display apparatus capable of

displaying characters with high resolution in any character color and any background color, by appropriately changing a predetermined correspondence between the above-described color element level and luminance level according to the color of a character to be displayed and the color of a background.

[0006]

Figure 12 is a block diagram showing a representative configuration of a character display apparatus disclosed in Japanese Laid-Open Publication No. 2001-100725 and Japanese Laid-Open Publication No. 2001-184051 described above.

[0007]

As the character display apparatus 1a, any information display apparatus including a display device capable of displaying color, such as an electronic apparatus, an information apparatus, and the like can be used. Examples of the character display apparatus 1a also include personal computers and word processors of any type, such as desktop, laptop, and the like. Further, an electronic apparatus including a color liquid crystal display device can be used. Still further, communication apparatuses (e.g., personal digital assistants, mobile telephones including PHS, general fixed telephones, FAX, etc.) can be used.

[0008]

The character display apparatus 1a includes a display device 3. This display device 3 is capable of displaying color. Examples of the display device 3 include liquid crystal displays, organic EL displays, and the like.

[0009]

The display device 3 is connected to a control section 20. The control section 20 includes a CPU 2 and a main memory 4.

The control section **20** can separately control a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. An input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**.

[0010]

The input device **7** is an apparatus for inputting characters to be displayed on the display device **3**, instructions of an operator, and the like. Examples of the input device **7** include keyboards, touch panels, mice, and the like.

[0011]

The auxiliary memory apparatus **40** stores a display program **41a** for displaying characters, and data **5** including character shape data **5b**, a correction table **5c** and a luminance table **5d**. Examples of the character shape data **5b** include outline data representing the contour shapes of characters, skeleton data representing the skeletal shapes of characters, bitmap data representing characters, and the like. Note that processing by the display program **41a** varies slightly depending on the type of the character shape data **5b**. Characters to be displayed may include simple graphics, such as pictographic characters and the like. In the descriptions below, characters are illustrated.

[0012]

The correction table **5c** is used to set the color element levels of sub-pixels neighboring a sub-pixel corresponding to a basic portion. For example, when the color element level of a sub-pixel corresponding to a basic portion is 7, the color element levels of its neighboring sub-pixels are set to be, for example, 5, 2 and 1 from the nearest to the basic portion. In addition, the luminance table **5d** defines a correspondence between color element levels and

luminance levels.

[0013]

Portion (a) of Figure 13 and Portion (b) of Figure 13 are diagrams for explaining the configuration of a display surface of the display device 3. The display surface of the display device 3 is provided with a plurality of pixels 10 for representing characters, graphics to be displayed, and the like as shown in Portion (a) of Figure 13. Each pixel 10 includes 3 sub-pixels 11 arranged in a predetermined direction (a horizontal direction in the figure), to which respective color elements (e.g., Red (R), Green (G), and Blue (B)) are assigned.

[0014]

When a character is displayed on the display surface, the basic portion representing the skeleton of the character is associated with sub-pixels 11 included in each pixel 10 to be displayed, based on the character shape data 5b. For example, when a Kanji character "忙" is displayed, sub-pixels indicated by hatched portions shown in Figure 9 are associated with the sub-pixels 11 as the basic portion representing the skeleton of the character.

[0015]

When associating the basic portion representing the skeleton of a character with sub-pixels 11, a different process is performed depending on the type of the character shape data 5b. For example, outline data contains a character code for identifying the type of a character, the number of strokes constituting a single character (the stroke count of a character), the number of contour points constituting a single stroke, the coordinates of contour points constituting a single stroke, and the like. In this case, each stroke has a shape enclosed by a contour line approximated by curved lines, straight lines, arcs, a

combination thereof, or the like, and a predetermined thickness so as to represent the contour shape of a character. A contour line representing the contour shape of a character can be approximated by straight lines, curved lines, arcs, a combination thereof, or the like, using the coordinate data of contour points. If an area where the inside of a contour line overlaps a sub-pixel is greater than or equal to a predetermined area, such a sub-pixel is determined as a basic portion representing the skeleton of a character.

[0016]

In addition, skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke (curved line, straight line, or the like), the coordinates of points constituting a single stroke, and the like. In this case, each stroke is in the form of a line corresponding to a certain line type for representing the skeletal shape of a character, and does not have a thickness. If the line type of a stroke is a straight line, the stroke can be approximated by a straight line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. If the line type of a stroke is a curved line, the stroke can be approximated by a curved line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. Sub-pixels **11** positioned on a stroke are determined as sub-pixels **12** corresponding to the basic portion representing the skeleton of a character.

[0017]

When a sub-pixel **12** corresponding to the basic portion representing the skeleton of a character is determined, the color element levels of the sub-pixel **12** and a sub-pixel **13**

neighboring the sub-pixel 12 are set. For example, when a sub-pixel 12 (hatched in Portion (b) of Figure 13), which is located at the middle of three sub-pixels 11 (Portion (a) of Figure 13) constituting a pixel 10, is determined to correspond to a basic portion, the color element level of the sub-pixel 12 corresponding to the basic portion is set, as shown in Portion (b) of Figure 13, to be "7" which is the maximum level. In addition, the color element levels of sub-pixels 13 which neighbor the sub-pixel 12 corresponding to the basic portion and are determined not to correspond to the basic portion, are set based on the correction table 5c whose example is shown in Figure 10. For example, when a correction pattern 1 is selected, the color element levels of the sub-pixels 13 which neighbor the sub-pixel 12 corresponding to the basic portion are set to be stepwise decreased, e.g., "5", "2", and "1" with an increase in the distance from the sub-pixel 12 corresponding to the basic portion. In addition, when a correction pattern 2 is selected, the color element levels of the sub-pixels 13 which neighbor the sub-pixel 12 corresponding to the basic portion, are set to be stepwise decreased, e.g., "4", "2", and "1" with an increase in the distance from the sub-pixel corresponding to the basic portion. Further, the color element level of sub-pixels 14, which are located at a distance of four pixels or more from the sub-pixel 12 corresponding to the basic portion, is set to be "0" as a background.

[0018]

Note that when a sub-pixel 13, which is determined not to correspond to a basic portion, neighbors a plurality of sub-pixels 12 corresponding to the basic portion, a plurality of color element levels may be set for the sub-pixel 13 depending on the distance from the plurality of sub-pixels 12 corresponding to the basic portion. In such a case, the color element level of the sub-pixel 13 is set to be the

greatest value.

[0019]

The color element level of each sub-pixel is converted to a luminance level based on a correspondence between color element levels and luminance levels set in the luminance table **5d** shown in Figure **11**. In the example of Portion **(b)** of Figure **13**, the luminance level of the sub-pixel **12** corresponding to the basic portion is set to be "0". The luminance level of a sub-pixel having a color element level of "5", which neighbors the sub-pixel **12**, is set to be "73". The luminance level of a sub-pixel having a color element level of "2" is set to be "182". The luminance level of a sub-pixel having a color element level of "1" is set to be "219". The luminance level of the sub-pixel **14**, whose color element level is set to "0" as a background, is set to be "255".

[0020]

Figure **14** is a flowchart showing a process flow of the display program **41a** when the character shape data **5b** is skeleton data.

[0021]

In step S1, a character code and a character size are input from the input device **7**. For example, when a Kanji character "木" is displayed on the display device **10**, 4458 (JIS KUTEN code, 44^{th} section and 58^{th} point) is input as a character code. The character size is represented by the number of dots in a horizontal direction and the number of dots in a vertical direction of a character to be displayed, e.g., 20 dots × 20 dots, for example.

[0022]

In step S2, skeleton data corresponding to the input character code is read from the character shape data **5b** in

the auxiliary memory apparatus **40** and is then stored in the main memory **4** of the control apparatus **20**. This skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke, the coordinates of points constituting a single stroke, and the like.

[0023]

In step S3, the coordinate data of points constituting each stroke contained in the skeleton data is scaled according to the character size input from the input device **7**. This scaling converts the coordinate data contained in the skeleton data defined in a predetermined coordinate system to a real pixel coordinate system for the display device **10**. In this case, the scaling is performed by considering the arrangement of sub-pixels. As shown in Portion **(a)** of Figure **13**, for example, one pixel **10** includes three sub-pixels **11** arranged in an X direction, and when a character size is 20 dots × 20 dots, the coordinate data of the skeleton data is scaled into data of 60(=20×3) pixels × 20 pixels.

[0024]

In step S4, the coordinate data of points constituting a single stroke is retrieved. In step S5, it is determined whether the type of stroke is a straight line or a curved line from the line type of the stroke contained in the skeleton data. When the type of stroke is a straight line, the process goes to step S6. When the type of stroke is a curved line, but not a straight line, the process goes to step S7.

[0025]

In step S6, the coordinate data of the points constituting the stroke are linked with straight lines, and sub-pixels positioned on the straight lines are defined as the basic portion representing the skeleton of a character. In

step S7, the coordinate data of the points constituting the stroke is approximated by curved lines, and sub-pixels positioned on the curved lines are defined as the basic portion representing the skeleton of a character.

[0026]

In step S8, the color element level of the sub-pixel corresponding to the basic portion representing the skeleton of the character, which is defined in step S6 or step S7 described above, is set to be the maximum color element level, for example, "7". Next, in step S9, the color element levels of sub-pixels neighboring the sub-pixel corresponding to the basic portion are set according to the correction table **5c**.

[0027]

In step S10, it is determined whether or not all strokes contained in a character have been processed. If "Yes", the process goes to step S11. If "No", the process returns to step S3 and is repeated. In step S11, the color element levels of the set sub-pixels are converted to respective luminance levels according to the luminance table **5d** indicating the correspondence between color element levels and luminance levels. In step S12, luminance data indicating the luminance levels of the sub-pixels set in step S11 is transferred to the display device **3**.

[0028]

In this manner, luminance levels are adjusted on a sub-pixel-by-sub-pixel basis to display a character on the display device **3**. In this case, sub-pixels corresponding to the basic portion representing the skeleton of a character are derived from the skeleton data. Alternatively, such sub-pixels may be derived from outline data, bitmap data, or the like by a predetermined process. Alternatively, the pattern of the basic portion which is previously stored as

character shape data in the auxiliary memory apparatus **40** may be read and used.

[0029]

[Problems to be Solved by the Invention]

However, in the above-described conventional technique, a pattern of the color element levels of sub-pixels constituting the shape of a character is set, and thereafter, the color element levels are converted to respective luminance levels which are actually to be displayed on a display section. Therefore, the process is complicated and a working memory area required for performing the process is increased. As a result, there are problems that character display processing is slowed, the hardware cost is increased, and the like.

[0030]

In addition, in the above-described conventional technique, when two or more strokes having a predetermined width are near to or cross each other, the space portion within a character is reduced so that it is difficult to recognize the shape of the character, i.e., "deformed character". To avoid this, a pattern of the color element levels of sub-pixels is changed. However, there is a problem that a complicated task is required in order to change a pattern of color element levels by actually recognizing the positional relationship between strokes.

[0031]

Further, when arbitrary colors are set to characters and backgrounds to be displayed, in some combination of the color of a character and the color of a background, a pattern of color element levels of sub-pixels is not suitable for representing the colors of the set character and background, thus causing a problem that the shape of the character is degraded and the visibility of the character is significantly

reduced.

[0032]

The present invention is intended to solve such problems of the conventional technique. The objective of the present invention is to provide: a character display apparatus and a character display method capable of displaying characters with high resolution and definition by a simple process, wherein the speed of character display processing is increased and the hardware cost can be decreased; a control program for controlling the character display method; and a recording medium having the control program recorded thereon.

[0033]

[Means for Solving the Problems]

A character display apparatus according to the present invention includes: a display section having a character displayed thereon; and a control section for controlling the display section, wherein a display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements is assigned to each sub-pixel, the control section determines, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character, extracts an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels, and determines luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0034]

The control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when a position of the sub-pixel corresponding to the basic portion is replaced with a position of its neighboring pixel.

[0035]

The control section can determine luminance levels of sub-pixels based on an arrangement of sub-pixels when, in addition to the sub-pixel corresponding to the basic portion, its neighboring sub-pixel is duplicated as the basic portion.

[0036]

The control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to a combination of a character color and a background color to be displayed.

[0037]

The control section can change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels according to the size of the difference between character and background colors previously registered and character and background colors to be displayed.

[0038]

In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a method according to the present invention for displaying a character on a display surface of the display section, includes the steps of: determining, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion

representing a skeleton of a character based on character shape data representing a shape of a character; extracting an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determining luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0039]

In a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, a control program according to the present invention is used when a character is displayed on a display surface of the display section, having a procedure described thereon for causing the control section to: determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character; extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0040]

A recording medium according to the present invention readable by a character display apparatus including a display section having a character displayed thereon including a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, at least a

corresponding one of a plurality of color elements being assigned to each sub-pixel, and a control section for controlling the display section, the recording medium includes a control program recorded thereon having a procedure described thereon for causing the control section to: determine, from a plurality of sub-pixels, a sub-pixel corresponding to a basic portion representing a skeleton of a character based on character shape data representing a shape of a character; extract an arrangement of sub-pixels corresponding to the basic portion from a sub-pixel contained in a pixel whose luminance level is to be determined and from its neighboring sub-pixels; and determine luminance levels of sub-pixels based on the extracted arrangement of the sub-pixels, thereby the objective described above is achieved.

[0041]

Functions of the present invention will be described below.

[0042]

According to the present invention, the display surface of the display section is provided with a plurality of pixels each containing a plurality of sub-pixels arranged in a predetermined direction, wherein at least a corresponding one of a plurality of color elements is assigned to each sub-pixel. When displaying a character on the display surface of the display section, sub-pixels corresponding to the basic portion representing the skeleton of a character are determined from the plurality of sub-pixels based on character shape data representing the shapes of characters, such as skeleton data representing the skeletal shapes of characters, outline data representing the contour shapes of characters, bitmap data representing the shapes of characters, or the like. From sub-pixels contained in a pixel whose luminance level is to be determined and its neighboring sub-pixels are determined, the arrangement of

the sub-pixels corresponding to the basic portion is extracted. Based on the extracted arrangement pattern of sub-pixels, the luminance levels of sub-pixels are determined, and the character is displayed on the display section.

[0043]

Therefore, as compared to a conventional technique in which the color element level of a sub-pixel corresponding to a basic portion and the color element levels of sub-pixels neighboring the sub-pixel corresponding to the basic portion are determined before the color element levels are used to determine the color luminance level of a pixel of interest, when displaying characters with high resolution and high definition, since luminance levels can be determined only by extracting arrangements of sub-pixels corresponding to a basic portion, processes can be simplified and the processes can be performed at practical speed even using a CPU having a low processing speed. Further, the size of a control program describing a procedure can be reduced, thereby making it possible to reduce the size of an auxiliary memory apparatus. Furthermore, the simplification of processes can reduce a working memory region required during processing. As a result, the cost of a character display apparatus can be reduced, thereby making it possible to realize a character display with high resolution and high definition.

[0044]

In addition, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the position of a sub-pixel corresponding to a basic portion is replaced with its neighboring sub-pixel. Based on such a replacing arrangement, the luminance levels of sub-pixels can be determined. Therefore, when

sub-pixels corresponding to the skeleton of a character are close to each other, the arrangement of sub-pixels can be changed so that such sub-pixels are spaced further apart. Thereby, it is possible to prevent a space between strokes of the character from being diminished, which deforms the character when strokes of the character are close to each other. The arrangement of sub-pixels corresponding to the skeleton of a character may not be suitable for the representation of the character, depending on a color combination of a character and a background. Even in this situation, by changing the arrangement of sub-pixels corresponding to the skeleton, distortion of the character can be corrected.

[0045]

Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, in addition to a sub-pixel corresponding to a basic portion, its neighboring sub-pixel is duplicated as a basic portion. Based on the duplicated arrangement, the luminance levels of the sub-pixels can be determined. Thus, a sub-pixel corresponding to the skeleton of a character can be multiplexed, thereby making it possible to simplify a process of thickening the line width of a character so that the process can be efficiently performed.

[0046]

Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels can be changed depending on a combination of a character color and a background color to be displayed. Therefore, the optimum luminance levels of sub-pixels can be determined

depending on a character color and a background color. Therefore, characters having an optimum line width can be displayed for each color combination, whereby characters can be displayed with a high level of visibility irrespective of the color combination.

[0047]

Further, according to the present invention, when the luminance levels of a plurality of sub-pixels are determined based on the arrangement of sub-pixels corresponding to a basic portion, the correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels can be changed according to the size of the difference between character and background colors previously registered and character and background colors to be displayed. Therefore, the above-described correspondence can be shared by a group of characters having similar color combinations (similar luminance levels of sub-pixels), whereby characters can be displayed with a greater variety of color combinations and an optimum line width while suppressing the storage capacity of a character display apparatus to a low level.

[0048]

[Embodiment of the Invention]

Hereinafter, the present invention will be described by way of illustrative examples with reference to the accompanying drawings.

[0049]

Figure **1** is a block diagram showing a configuration of a character display apparatus according to an embodiment of the present invention. As the character display apparatus **1b**, any information display apparatus including a display device capable of displaying color, such as an electronic apparatus, an information apparatus, and the like can be used. Examples of the character display apparatus **1b**

also include personal computers and word processors of any type, such as desktop, laptop, and the like. Further, examples of the character display apparatus **1b** also include electronic apparatuses including a color liquid crystal display device, such as communication apparatuses (e.g., personal digital assistants, mobile telephones including PHS, general fixed telephones, FAX, etc.).

[0050]

The character display apparatus **1b** includes a display device **3**. This display device **3** is capable of displaying color. Examples of the display device **3** include liquid crystal displays, organic EL displays, and the like.

[0051]

The display device **3** is connected to a control section **20**. The control section **20** includes a CPU **2** and a main memory **4**. The control section **20** can separately control a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. An input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**.

[0052]

The input device **7** is an apparatus for inputting characters to be displayed on the display device **3**, instructions of an operator, and the like. Examples of the input device **7** include keyboards, touch panels, mice, and the like.

[0053]

The auxiliary memory apparatus **40** stores a display program **41b** for displaying characters and data **5** containing character shape data **5b** and a pixel value table **5e**. Examples of the character shape data **5b** include outline data representing the contour shapes of characters, skeleton data representing the skeletal shapes of characters, bitmap data

representing characters, and the like. Note that processing by the display program **41b** varies slightly depending on the type of the character shape data **5b**. Characters to be displayed may include simple graphics, such as pictographic characters and the like. In descriptions below, characters are illustrated.

[0054]

The pixel value table **5e** contains a correspondence between the arrangement pattern of a basic portion comprising M+2×N sub-pixels including M sub-pixels contained in a pixel (pixel of interest) whose luminance level is determined and N sub-pixels neighboring each side of the M sub-pixels, and the luminance levels (pixel value) of the M sub-pixels contained in the pixel of interest.

[0055]

Portion **(a)** of Figure 2 to Portion **(c)** of Figure 2 are diagrams for explaining the configuration of a display surface of the display device **3**. The display surface of the display device **3** is provided with a plurality of pixels **10** for representing characters, graphics to be displayed, and the like as shown in Portion **(a)** of Figure 2. Each pixel **10** includes 3 sub-pixels **11** arranged in a predetermined direction (a horizontal direction in the figure), to each of which a corresponding color element of a plurality of color elements (e.g., Red (R), Green (G), and Blue (B)) is assigned.

[0056]

When a character is displayed on the display surface, the basic portion representing the skeleton of the character is associated with sub-pixels **11** included in pixels **10** to be displayed, based on the character shape data **5b**. For example, when a Kanji character "忙" is displayed, the basic portion representing the skeleton of the character is

associated with sub-pixels **11** indicated by hatched portions shown in Figure **9**.

[0057]

When the basic portion representing the skeleton of a character is associated with sub-pixels **11**, a different process is performed depending on the type of the character shape data **5b**. For example, outline data contains a character code for identifying the type of a character, the number of strokes constituting a single character (the stroke count of a character), the number of contour points constituting a single stroke, the coordinates of contour points constituting a single stroke, and the like. In this case, each stroke has a shape enclosed by a contour line approximated by curved lines, straight lines, arcs, a combination thereof, or the like, and a predetermined thickness so as to represent the contour shape of a character. A contour line representing the contour shape of a character can be approximated by straight lines, curved lines, arcs, a combination thereof, or the like, using the coordinate data of contour points. If an area where the inside of a contour line overlaps a sub-pixel is greater than or equal to a predetermined area, such a sub-pixel is determined to correspond to a basic portion representing the skeleton of a character.

[0058]

In addition, skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke, the line type of a stroke (curved line, straight line, or the like), the coordinates of points constituting a single stroke, and the like. In this case, each stroke is in the form of a line corresponding to a certain line type for representing the skeletal shape of a character, and does not have a thickness. If the line

type of a stroke is a straight line, the stroke can be approximated by a straight line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. If the line type of a stroke is a curved line, the stroke can be approximated by a curved line passing through a plurality of points constituting the stroke using the coordinate data of the plurality of points constituting the stroke. Sub-pixels **11** positioned on a stroke are determined as sub-pixels **12** corresponding to the basic portion representing the skeleton of a character.

[0059]

The bitmap data has binary values. Each bit constituting the bitmap data has a value of "1" or "0". A bit having a value of "1" represents a black portion in a graphic. A bit having a value of "0" represents a white portion in a graphic. A basic portion of a graphic corresponds to a core in a graphic. When a graphic is a character, the basic portion is, for example, a middle portion of a stroke contained in a character. However, in the bitmap data, stroke information is lost. Thus, bits in the bitmap data are associated with the basic portion by inference. The basic portion cannot be inferred only by information of bit D(x, y) of interest. However, the basic portion is inferred based on information of neighboring bits around bit D of interest. It is initially determined whether or not each bit constituting the bitmap data is "1", so as to examine the "1"/"0" arrangement pattern of neighboring bits around the bit of interest. The bit of interest is associated with a pixel. Among the sub-pixels contained in the pixel to which the bit of interest corresponds, a sub-pixel **12** corresponding to the basic portion is determined according to the arrangement pattern of the neighboring bits.

[0060]

Figure 15 is a diagram showing a portion of bitmap data representing a graphic. D(x, y) represents a bit of interest. N(a, b) represents neighboring bit D(x+a, y+b) around D(x, y). Figure 15 shows eight neighboring bits N(-1, 1), N(0, -1), N(1, -1), N(-1, 0), N(1, 0), N(-1, 1), N(0, 1), and N(1, 1) neighboring bit D(x, y) in a vertical, horizontal, or slant direction. These eight neighboring bits are called eight neighbors. N(a, b) and D(x, y) each have a value of "1" or "0".

[0061]

Figure 16 is a diagram showing a portion of the display surface of a display device. P(x, y) represents a pixel on the display surface. Bit D(x, y) shown in Figure 15 is associated with pixel P(x, y) when a graphic represented by bitmap data is displayed on a display device. P(x, y) contains three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y). When D(x, y) has a value of "1", a sub-pixel corresponding to a basic portion is determined among the three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y) according to a basic-portion definition rule. When D(x, y) has a value of "0", none of the three sub-pixels is determined as a sub-pixel corresponding to the basic portion. Note that although bit D(x, y) shown in Figure 15 is associated with a sub-pixel group Grp shown in Figure 16, the number of sub-pixels contained in a group and the number of sub-pixels contained in a pixel are not necessarily equal to each other. For example, a bit in the bitmap data may be associated with a group Grp' consisting of four sub-pixels shown in Figure 16. In addition, the direction of arrangement of sub-pixels contained in a group is not limited to an X direction. For example, a bit in the bitmap data may be associated with a group Grp" in which sub-pixels are arranged in the X direction and the Y direction shown in Figure 16.

[0062]

Figure **17A** shows an example of 8 neighboring bits of a bit of interest D(x, y) in the bitmap data. Bit N(a, b) having a value of "1" is represented by N(a, b). In Figure **17A**, N(0, -1) = N(1, 1) = 1, N(1, 0) = N(0, 1) = N(-1, 1) = N(-1, 0) = 0, and N(-1, -1) and N(1, -1) represented by "※" has any one of "0" and "1". Figure **17B** is a diagram showing a sub-pixel which is associated with the basic-portion according to a basic-portion definition rule when 8 neighboring bits of bit D(x, y) have values shown in Figure **17A**. According to the basic-portion definition rule, whether or not each of three sub-pixels contained in pixel P(x, y) is associated with a basic portion is determined according to the arrangement of "0" and "1" of neighboring bits N(a, b) around bit D(x, y) associated with pixel P(x, y) as follows. Note that bit D(x, y) is assumed to have a value of "1" in the description below. As shown in Figure **15**, pixel P(x, y) on the display surface associated with bit D(x, y) contains three sub-pixels C(3x, y), C(3x+1, y) and C(3x+2, y). Among these sub-pixels, a sub-pixel indicated by a value of "1" in Figure **17B** is associated with a basic portion, while sub-pixels indicated by a value of "0" are not associated with a basic portion. Specifically, sub-pixel C(3x+2, y) is associated with a basic portion, while C(3x, y) and C(3x+1, y) are not associated with a basic portion. For example, in the bitmap data shown in Figure **17A**, a stroke is inferred to be a curved line (dashed line **50** in Figure **16A**) which passes through areas corresponding to bits N(0, -1), D(x, y), and N(1, 1). Such a curved line is considered to pass through the right-hand side of an area corresponding to bit D(x, y). Therefore, in Figure **17B**, sub-pixel C(3x+2, y) on the right-hand side of pixel P(x, y) corresponding to bit D(x, y) is associated with a basic portion.

[0063]

When a sub-pixel **12** corresponding to the basic portion representing the skeleton of a character is determined, the color element levels of the sub-pixel **12** and a sub-pixel **13** neighboring the sub-pixel **12** are determined. For example, when a sub-pixel **12** (hatched in Portion **(b)** of Figure **2**), which is located at the middle of three sub-pixels **11** (Portion **(a)** of Figure **2**) constituting a pixel **10**, is determined to correspond to a basic portion, the color element level of the sub-pixel **12** corresponding to the basic portion is set, as shown in Portion **(b)** of Figure **2**, to be "7" which is the maximum level. In addition, the color element levels of sub-pixels **13** which neighbor the sub-pixel **12** corresponding to the basic portion and are determined not to correspond to the basic portion, are set to be stepwise decreased, e.g., "5", "2", and "1" with an increase in the distance from the sub-pixel **12** corresponding to the basic portion. Further, the color element level of sub-pixels **14**, which are located at a distance of four pixels or more from the sub-pixel **12** corresponding to the basic portion, is set to be "0" as a background.

[0064]

Note that when a sub-pixel **13**, which is determined not to correspond to a basic portion, neighbors a plurality of sub-pixels **12** corresponding to the basic portion, a plurality of color element levels may be set for the sub-pixel **13** depending on the distance from the plurality of sub-pixels **12** corresponding to the basic portion. In such a case, the color element level of the sub-pixel **13** is set to be the greatest value.

[0065]

The color element level of each sub-pixel is converted to a luminance level based on to a correspondence between color element levels and luminance levels. In the example of Portion **(b)** of Figure **2**, the luminance level of the

sub-pixel 12 corresponding to the basic portion is set to be "0". In addition, the luminance level of a sub-pixel having a color element level of "5", which neighbors the sub-pixel 12, is set to be "73". The luminance level of a sub-pixel having a color element level of "2" is set to be "182". The luminance level of a sub-pixel having a color element level of "1" is set to be "219". The luminance level of the sub-pixel 14, whose color element level is set to "0" as a background, is set to be "255".

[0066]

When a luminance level is determined in this manner, in the present embodiment, as shown in Portion (c) of Figure 3, the arrangement of a basic portion is extracted from M+2×N sub-pixels including M sub-pixels 16 contained in a pixel (pixel of interest) 15 whose luminance level is to be determined and N sub-pixels 17 neighboring on each side of pixel 15. Based on the extracted arrangement pattern, the luminance levels (i.e., pixel value) of M sub-pixels 16 contained in the pixel 15 of interest are determined.

[0067]

Figure 3 is a diagram showing an example of the pixel value table 5e. In Figure 3 and Figures 4 to 7, the description will be given regarding the case in which the number (M) of the sub-pixels 16 contained in the pixel 15 of interest shown in Portion (c) of Figure 2 is 3 (M=3), and the number (N) of the sub-pixels 17 neighboring on each side of the pixel 15 is 3 (N=3). Note that the number N of the above-described pixels is typically the same as the number of elements in a correction pattern (N=3 in Figure 10). The left-hand side of Figure 3 shows an arrangement pattern of 9 sub-pixels contained in 3 pixels (the pixel 15 of interest and pixels on the both sides thereof) which are arranged in the same direction as that of the arrangement of the sub-pixels. In the figure, element "0" indicates that a

basic portion is not assigned to a sub-pixel relating to the element; element "1" indicates that a basic portion is assigned to a sub-pixel relating to the element; and element "x" indicates that either a basic portion is assigned to a sub-pixel relating to the element or a basic portion is not assigned to a sub-pixel relating to the element. In addition, the right-hand side of Figure 3 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest corresponding to the arrangement pattern on the left side of Figure 3.

[0068]

The pixel value of a pixel is determined using the pixel value table 5e indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value (the luminance levels of sub-pixels) is to be determined.

[0069]

For example, in the case in which the arrangement of sub-pixels corresponding to a basic portion is "x10 000 01x", for example, when the correction pattern 1 shown in Figure 10 is selected, the arrangement of the color element levels is "x75, 212, 57x". The color element levels (2, 1, 2) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 219, 182) according to the correspondence between color element levels and luminance levels shown in Figure 11. Therefore, in the pixel value table 5e of Figure 3, the arrangement pattern "x10 000 01x" of the sub-pixels corresponding to a basic portion and the pixel values (182, 219, 182) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0070]

Figure 4 is a diagram showing another example of the pixel value table 5e. The left-hand side of Figure 4 shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. The right-hand side of Figure 4 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest corresponding to the arrangement pattern on the left side of Figure 4.

[0071]

The pixel value of a pixel is determined using the pixel value table 5e indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0072]

For example, in the case in which the arrangement of sub-pixels corresponding to a basic portion is "000 001 000", when the correction pattern 1 shown in Figure 10 is selected, the arrangement of the color element levels is "001, 257, 521". The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 73, 0) according to the correspondence between color element levels and luminance levels shown in Figure 11. Therefore, in the pixel value table 5e of Figure 4, the arrangement pattern "000 001 000" of the sub-pixels corresponding to a basic portion and the pixel values (182, 73, 0) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0073]

As described above, the correspondence between the

arrangement pattern of sub-pixels corresponding to a basic portion and the luminance values of the sub-pixels is preset in the pixel value table **5e**. Therefore, when sub-pixels corresponding to a basic portion are near each other, the pixel values of pixels present between strokes of a character can be controlled by adjusting the luminance values of sub-pixels corresponding to the arrangement pattern. Therefore, it is possible to prevent black pixels from filling between strokes of a character, i.e., space within the character is diminished, or the like. Thus, the quality of display can be improved.

[0074]

Figure **5** is a diagram showing another example of the pixel value table **5e**. Herein, a basic portion is moved so as to prevent a space within a character from being diminished. The left-hand side of Figure **5** shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. In addition, the middle of Figure **5** shows an arrangement pattern, in which sub-pixels corresponding to a basic portion are replaced with the sub-pixels located at the middle of three sub-pixels contained in each pixel. The right-hand side of Figure **5** shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the middle of Figure **5**.

[0075]

The pixel value of a pixel is determined using the pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0076]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "000 001 000", the arrangement of the sub-pixels is changed to "000 010 000" by replacement of the basic portion. Due to this, when the correction pattern 1 shown in Figure 10 is selected, the arrangement of the color element levels is "012, 575, 210", and the color element levels (5, 7, 5) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (73, 0, 73) according to the correspondence between color element levels and luminance levels shown in Figure 11. Therefore, in the pixel value table 5e of Figure 5, the arrangement pattern "000 001 000" of the sub-pixels corresponding to a basic portion and the pixel values (73, 0, 73) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0077]

Figure 6 is a diagram showing another example of the pixel value table 5e. Herein, a duplicate of a basic portion is provided on the left side of the basic portion to thicken the line width of a character (multiplexing). The left-hand side of Figure 6 shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels and a sub-pixel neighboring on the right-hand side thereof. The middle of Figure 6 shows an arrangement pattern, in which in addition to a sub-pixel corresponding to a basic portion, a sub-pixel located on the left-hand side of that pixel is duplicated as a basic portion. The right-hand side of Figure 6 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the middle of Figure 6.

[0078]

The pixel value of a pixel is determined using the pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0079]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "x10 000 01x x", the arrangement of the sub-pixels is changed to "x10 010 11x x" by providing a duplicate of the basic portion to the left-hand side of the sub-pixel. Due to this, when the correction pattern 1 shown in Figure **10** is selected, the arrangement of the color element levels is "x75, 225, 77x, x". The color element levels (2, 2, 5) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 182, 73) according to the correspondence between color element levels and luminance levels shown in Figure **11**. Therefore, in the pixel value table **5e** of Figure **6**, the arrangement pattern "x10 000 01x x" of the sub-pixels corresponding to a basic portion and the pixel values (182, 182, 73) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0080]

Figure **7** is a diagram showing another example of the pixel value table **5e**. Figure **7** shows a correspondence between the arrangement of sub-pixels corresponding to a basic portion and the pixel values (R, G, B) of pixels, where the color of a background is orange, i.e., (R, G, B) = (255, 127, 0). The left-hand side of Figure **7** shows an arrangement pattern of 9 sub-pixels contained in 3 pixels which are arranged in the same direction as that of the arrangement of the sub-pixels. The right-hand side of Figure **7** shows

the luminance value of each sub-pixel (R, G, B) contained in a pixel of interest, corresponding to each arrangement pattern in the left-hand side of Figure 7.

[0081]

The pixel value of a pixel is determined using the pixel value table 5e indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined.

[0082]

For example, when the arrangement of sub-pixels corresponding to a basic portion is "000 000 000", there is no sub-pixel corresponding to the basic portion of a character. A pixel whose pixel value is to be determined corresponds to a background. Therefore, the luminance value of (R, G, B) is (255, 127, 0).

[0083]

The color element levels of sub-pixels neighboring a basic portion, which are stepwise changed, are adjusted according to the distribution of luminance in the background color. For example, in the case in which the arrangement of sub-pixels corresponding to the basic portion is "000 001 000", when the background color is white, the arrangement of color element levels is "001,257,521" as shown in Figure 4. The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel of interest whose pixel value is to be determined are converted to luminance levels (182, 73, 0). In contrast, when the background color is orange, the ratio of the luminance levels (R, G, B) is (1, 1/2, 0). Therefore, the color element levels (2, 5, 7) of the sub-pixels (R, G, B) contained in the pixel of interest whose pixel value is to be determined are adjusted to luminance levels (182, 36, 0) where the level of G becomes $73 \times 1/2 \fallingdotseq 36$.

Thus, in the pixel value table **5e** of Figure **7**, the arrangement pattern "000 001 000" of the sub-pixels corresponding to the basic portion and the adjusted pixel values (182, 36, 0) of the pixel are associated with each other. Similarly, the other arrangement patterns and the pixel values of pixels are associated with each other.

[0084]

A correspondence between the arrangement of sub-pixels and the pixel value of a pixel to be set for arbitrary character color and background color can be adjusted according to the character color and background color based on the pixel value table **5e** indicating a correspondence for a basic color combination, i.e., black characters in a white background as shown in Figures **3** and **4**. For each color combination, the pixel value of a pixel can be determined according to a pixel value table **5e** as shown in Figure **7**.

[0085]

For each combination of a character color and a background color, a pixel value table as shown in Figure **7** described above may be provided, or the values of a pixel value table as shown in Figures **3** and **4** described above may be adjusted so as to determine a correspondence between the arrangement of sub-pixels and a pixel value. Further, when there are a number of combinations of a character color and a background color, similar colors may be grouped and pixel value tables indicating a correspondence are provided for respective representative colors, and pixel value tables indicating a correspondence may be adjusted according to the size of a difference between the character and background colors and the representative color. For example, the sum of squares of differences between each color element (R, G, B), the sum of absolute differences between each color element (R, G, B), or the like, can be used as an indicator for determining the size of a color difference. A difference

in color element level in color space (e.g., YUV space, Lab space, or the like) according to visual characteristics may be used as an indicator for determining a color difference. If a difference between a representative color assigned to the above-described pixel value table indicating a correspondence and a color specified in displaying a character is less than or equal to a predetermined threshold, the specified color is determined as a color belonging to a group including the representative color and the pixel value table can be used to determine the pixel value of a pixel.

[0086]

The above-described pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels and the pixel value of a pixel has $2^{(M+2\times N)}$ entries of arrangement combinations of sub-pixels, i.e., the combinations of the presence or absence ("1" or "0") of a basic portion in (M+2×N) sub-pixels. For example, if M=N=3, the number of entries is 512. As shown in Figure **10**, however, correction patterns are set, in which the color element levels of sub-pixels neighboring a sub-pixel corresponding to a basic portion are stepwise changed. Therefore, the sequence of the luminance values of sub-pixels is limited. In addition, when correction patterns overlap in a sub-pixel, the larger color element level is set in the sub-pixel. Therefore, the number of pixel values obtained by combinations of sub-pixels is 5×N+8 where M=3. Therefore, if M=N=3, the number of pixel values is 23. By assigning 23 indexes to 512 arrangement patterns, a data capacity required for storing pixel values actually set can be reduced as compared to when a total of 24-bit full color data is prepared in a table where each of (R, G, B) has a length of 8 bit (=0 to 255), for example. However, note that the number of combinations described above is not limited to 23 obtained from the above-described expression in order to set pixel

values more precisely.

[0087]

As described above, in a correspondence between the arrangement of sub-pixels and luminance levels of pixels, the sub-pixel of interest is arranged in a direction along which, for example, R, G, and B are arranged. However, the present invention is not so limited. Alternatively, a similar correspondence can be used for other arrangements, for example in the case in which the sub-pixel of interest is arranged in a direction perpendicular to which, for example, R, G, and B are arranged.

[0088]

Figure **8** is a flowchart indicating a process flow of the display program **41b** when the character shape data **5b** is skeleton data.

[0089]

In step S1, a character code and a character size are input from the input device **7**. For example, when a Kanji character "木" is displayed on the display device **10**, 4458 (JIS KUTEN code, 44^{th} section and 58^{th} point) is input as a character code. The character size is represented by the number of dots in a horizontal direction and the number of dots in a vertical direction of a character to be displayed, e.g., 20 dots × 20 dots, for example.

[0090]

In step S2, skeleton data corresponding to the input character code is read from the character shape data **5b** in the auxiliary memory apparatus **40** and is then stored in the main memory **4** of the control apparatus **20**. This skeleton data contains a character code for identifying the type of a character, the number of strokes constituting a single character, the number of points constituting a single stroke,

the line type of a stroke, the coordinates of points constituting a single stroke, and the like.

[0091]

In step S3, the coordinate data of points constituting each stroke contained in the skeleton data is scaled according to the character size input from the input device 7. This scaling converts a predetermined coordinate system for the coordinate data contained in the skeleton data to a real pixel coordinate system defined for the display device 10. In this case, the scaling is performed by considering the arrangement of sub-pixels. As shown in Portion (a) of Figure 13, for example, one pixel 10 includes three sub-pixels 11 arranged in an X direction, and when a character size is 20 dots × 20 dots, the coordinate data of the skeleton data is scaled into data of 60(=20×3) pixels × 20 pixels.

[0092]

In step S4, the coordinate data of points constituting a single stroke is retrieved.

[0093]

In step S5, it is determined whether the type of the stroke is a straight line or a curved line from the line type of the stroke contained in the skeleton data. When the type of the stroke is a straight line, the process goes to step S6. When the type of the stroke is a curved line, but not a straight line, the process goes to step S7.

[0094]

In step S6, the coordinate data of the points constituting the stroke are linked with straight lines, and sub-pixels positioned on the straight lines are defined as the basic portion representing the skeleton of a character. In step S7, the coordinate data of the points constituting the stroke is approximated by curved lines, and sub-pixels

positioned on the curved lines are defined as the basic portion representing the skeleton of a character.

[0095]

In step S10, it is determined whether or not all strokes contained in a character have been processed. If "Yes", the process goes to step S101. If "No", the process returns to step S3 and is repeated.

[0096]

In step S101, the arrangement of sub-pixels corresponding to a basic portion representing a skeleton of a character defined in above-described step S6 or step S7 is extracted from the sub-pixels contained in a pixel whose pixel value (the luminance levels of sub-pixels) is to be determined and from its neighboring sub-pixels.

[0097]

In step S102, a pixel value corresponding to the arrangement pattern of the basic portion extracted in step S101 is set as the luminance levels of sub-pixels contained in the pixel of interest according to the pixel value table 5e indicating a correspondence between the arrangement pattern of sub-pixels corresponding to a basic portion and the pixel value (the luminance levels of sub-pixels) of a pixel.

[0098]

In step S12, luminance data indicating the luminance levels of the sub-pixels set in step S102 is transferred to the display device 3.

[0099]

As described above, the luminance level can be adjusted on a sub-pixel-by-sub-pixel basis based on the arrangement of sub-pixels corresponding to a basic portion for the purpose of displaying a character on the display device 3. Herein,

sub-pixels corresponding to the basic portion representing the skeleton of a character are derived from skeleton data. Alternatively, such sub-pixels may be derived from outline data, bitmap data, or the like by a predetermined process. Alternatively, the pattern of the basic portion which is previously stored as character shape data in the auxiliary memory apparatus **40** may be read and used.

[0100]

[Effect of the Invention]

As described above, according to the present invention, when a character is displayed with high resolution on a display section capable of displaying color, a luminance level to be displayed on the display section can be obtained directly by converting the arrangement of sub-pixels corresponding to the basic portion representing the skeleton of a character. Therefore, the character display process can be performed at a higher rate and a working memory area for performing the character display process can be reduced. As a result, character display processing can be performed at a higher rate and the hardware cost can be reduced.

[0101]

In addition, when character strokes are close to each other, the positions of sub-pixels corresponding to the basic portion representing the skeleton of a character can be adjusted to easily prevent deformation of a character. Further, in addition to a sub-pixel corresponding to the basic portion representing the skeleton of a character, the arrangement of its neighboring sub-pixels is adjusted so as to be a sub-pixel for the basic portion, thereby making it possible to easily increase the line width of the character.

[0102]

Further, in the case in which arbitrary color is set to a

character and a background to be displayed, it is possible, by changing a correspondence between the arrangement of sub-pixels and the luminance levels of sub-pixels according to the character color and the background color, to provide a character display in which the shape of a character is retained and a high level of visibility is achieved irrespective of a color combination.

[0103]

Further, in a correspondence between the arrangement of sub-pixels corresponding to a basic portion and the pixel value of a pixel, similar combinations of a character color and a background color may be grouped for arbitrary combination of characters and backgrounds so as to be merged into a correspondence table for a representative color combination. Therefore, a data amount required for a correspondence table between the arrangement of sub-pixels corresponding to a basic portion and the pixel value of a pixel can be reduced.

[Brief Description of the Drawings]

[Figure 1]

Figure 1 is a block diagram showing a configuration of a character display apparatus according to an embodiment of the present invention.

[Figure 2]

Portions (a) to (c) of Figure 2 are diagrams for explaining a configuration of sub-pixels and a correction pattern in a character display apparatus according to an embodiment of the present invention.

[Figure 3]

Figure 3 is a diagram showing an example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 4]
Figure 4 is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 5]
Figure 5 is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 6]
Figure 6 is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 7]
Figure 7 is a diagram showing another example of a pixel value table in a character display apparatus according to an embodiment of the present invention.

[Figure 8]
Figure 8 is a flowchart for explaining a character display method according to an embodiment of the present invention.

[Figure 9]
Figure 9 is a diagram showing an exemplary pattern of sub-pixels corresponding to a basic portion for a Kanji character "忙".

[Figure 10]
Figure 10 is a diagram showing an exemplary correction table in a conventional character display apparatus.

[Figure 11]
Figure 11 is a diagram showing an exemplary luminance table

in a conventional character display apparatus.

[Figure 12]
Figure **12** is a block diagram showing a configuration of a conventional character display apparatus.

[Figure 13]
Portions **(a)** and **(b)** of Figure **13** are diagrams for explaining a configuration of sub-pixels and a correction pattern in a conventional character display apparatus.

[Figure 14]
Figure **14** is a flowchart for explaining a conventional character display method.

[Figure 15]
Figure **15** is a diagram showing a portion of bitmap data representing graphics.

[Figure 16]
Figure **16** is a diagram showing a portion of a display surface of a display device.

[Figure 17A]
Figure **17A** is a diagram showing an example of a bit of interest and its 8 neighbors in bitmap data.

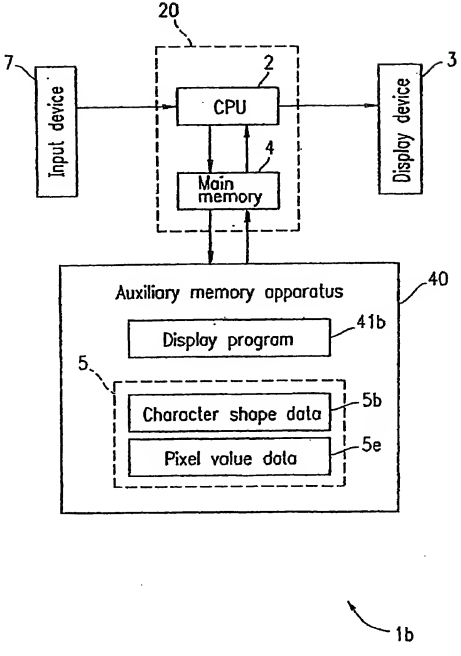
[Figure 17B]
Figure **17B** is a diagram showing a sub-pixel associated with a basic portion according to a basic-portion definition rule in the bit of interest and its 8 neighbors shown in Figure **17A**.

[Description of the Reference Numerals]
1a, 1b character display apparatus
2 CPU
3 display device

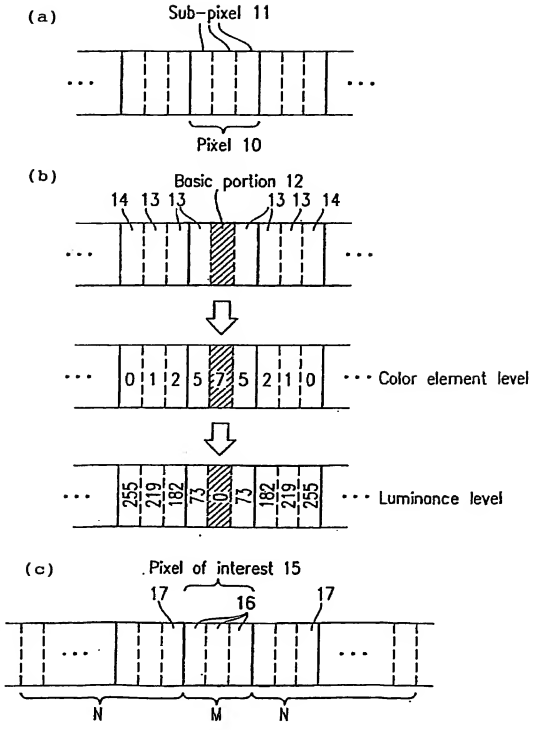
4 main memory
5 data
5b character shape data
5c correction table
5d luminance table
5e pixel value table
7 input device
10 pixel
11 sub-pixel
12 sub-pixel corresponding to the basic portion representing the skeletal shape of a character
13 sub-pixel which neighbors the sub-pixel corresponding to a basic portion
14 sub-pixel which is located at a distance of four pixels or more from the sub-pixel corresponding to the basic portion
15 pixel of interest
16 sub-pixel contained in the pixel of interest
17 sub-pixel which neighbors the pixel of interest
40 auxiliary memory apparatus
41a, 41b display program

[Name of the Document] DRAWINGS

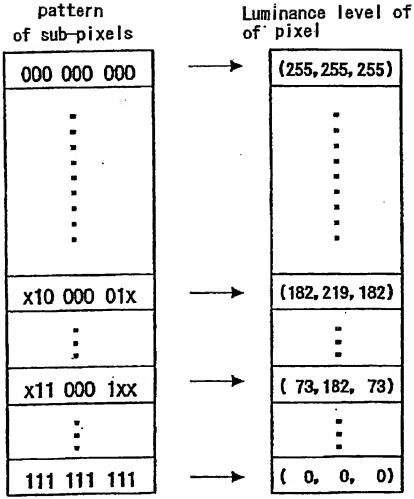
[Figure 1]



[Figure 2]

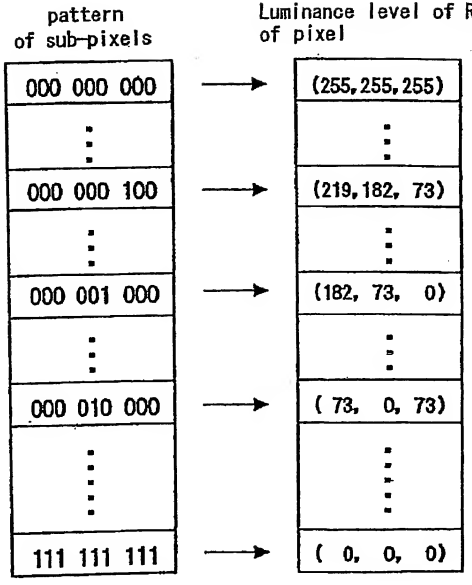

(a)
Sub-pixel 11
Pixel 10
(b)
Basic portion 12
14 13 13 13 13 13 14
0 1 2 5 7 5 2 1 0
Color element level
255 219 182 73 0 73 182 219 255
Luminance level
(c)
Pixel of interest 15
17 16 17
N M N

[Figure 3]



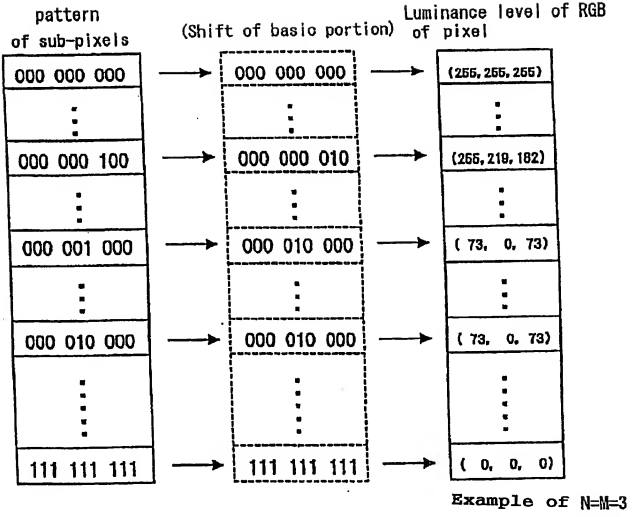
Example of N=M=3

[Figure 4]



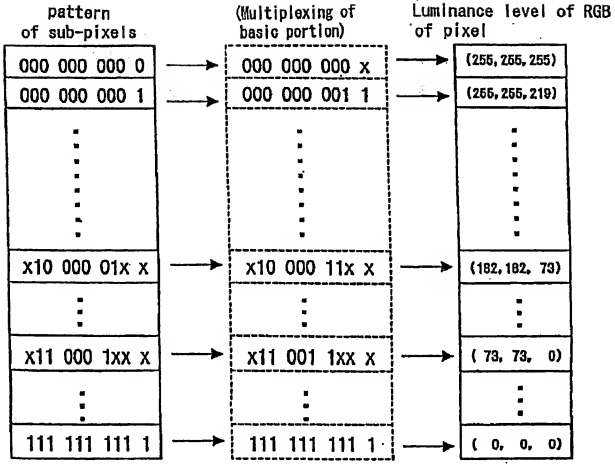
Example of N=M=3

[Figure 5]



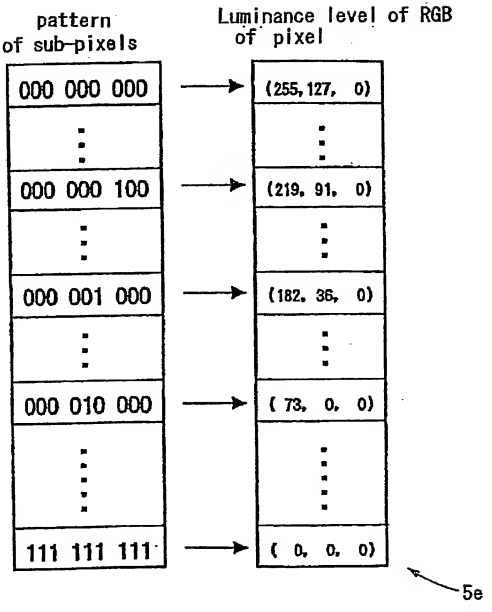
Example of N=M=3

[Figure 6]



Example of N=M=3

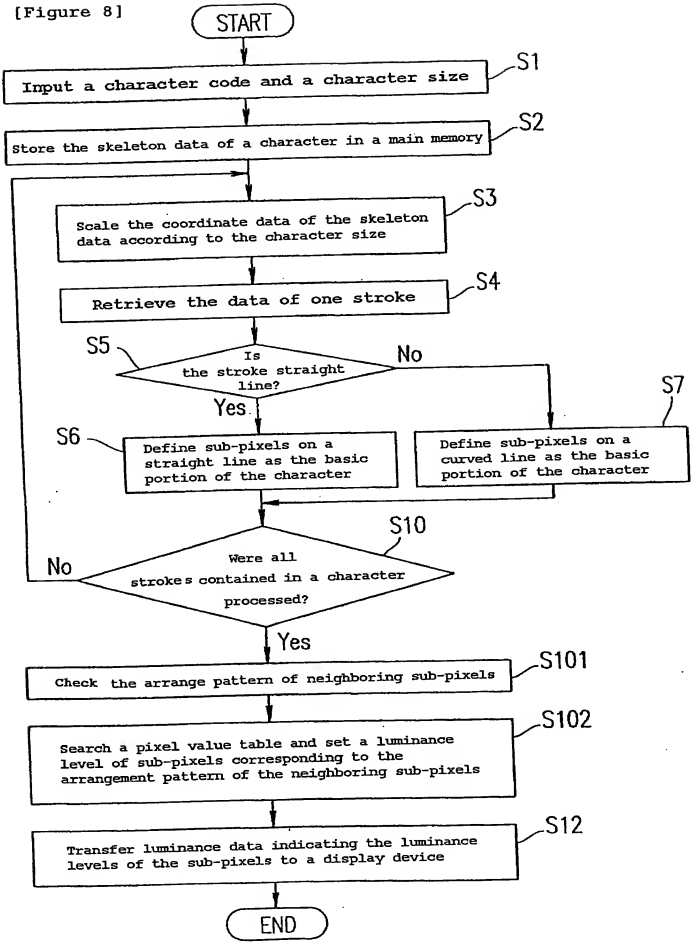
[Figure 7]



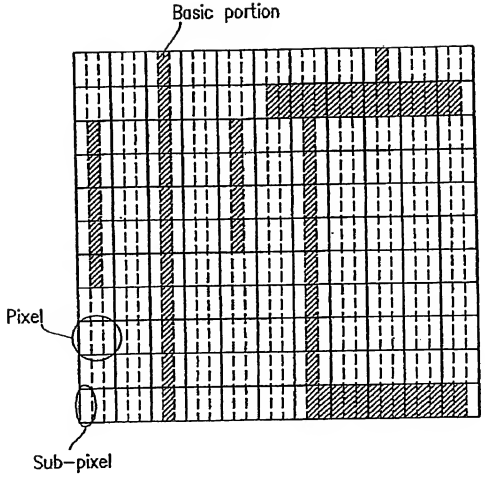
When Background color is orange
(255, 127, 0)

Example of N=M=3

[Figure 8]


START
Input a character code and a character size
S1
Store the skeleton data of a character in a main memory
S2
Scale the coordinate data of the skeleton data according to the character size
S3
Retrieve the data of one stroke
S4
S5
Is the stroke straight line?
No
Yes
S6
Define sub-pixels on a straight line as the basic portion of the character
S7
Define sub-pixels on a curved line as the basic portion of the character
S10
Were all strokes contained in a character processed?
No
Yes
Check the arrange pattern of neighboring sub-pixels
S101
Search a pixel value table and set a luminance level of sub-pixels corresponding to the arrangement pattern of the neighboring sub-pixels
S102
Transfer luminance data indicating the luminance levels of the sub-pixels to a display device
S12
END

[Figure 9]



[Figure 10]

Correction table 5c

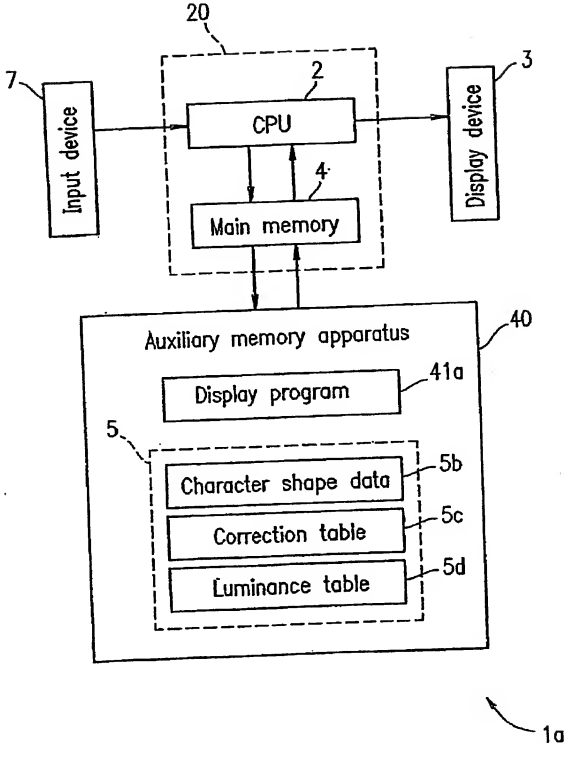
		Correction pattern 1	Correction pattern 2
Color element level	Sub-pixel 1	5	4
	Sub-pixel 2	2	2
	Sub-pixel 3	1	1

[Figure 11]

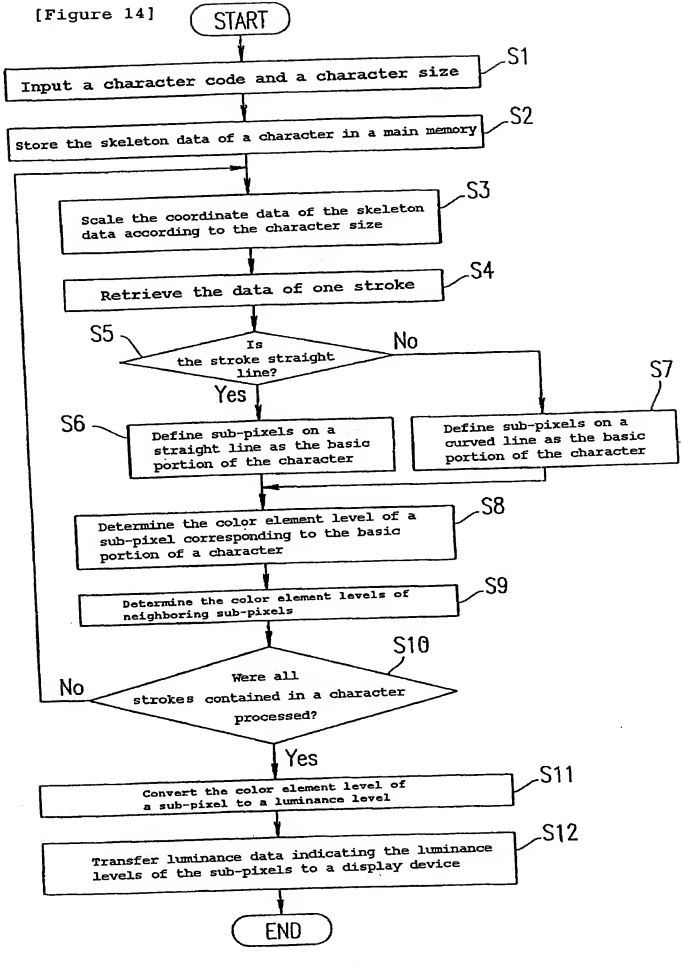
Luminance toble 5d

		Luminance level		
		R	G	B
Color element level	7	0	0	0
	6	36	36	36
	5	73	73	73
	4	109	109	109
	3	146	146	146
	2	182	182	182
	1	219	219	219
	0	255	255	255

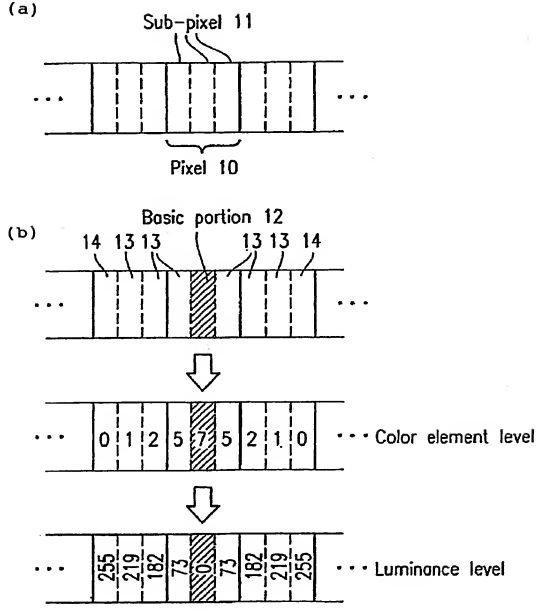
[Figure 12]


20
7
Input device
2
CPU
3
Display device
4
Main memory
Auxiliary memory apparatus
40
Display program
41a
5
Character shape data
5b
Correction table
5c
Luminance table
5d
1a

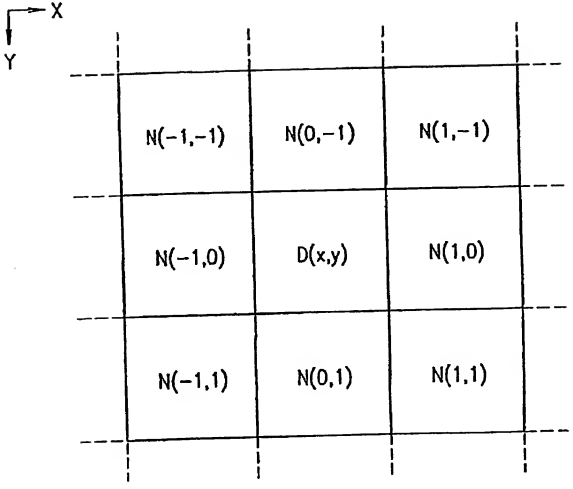
[Figure 14]


START
Input a character code and a character size
S1
Store the skeleton data of a character in a main memory
S2
Scale the coordinate data of the skeleton data according to the character size
S3
Retrieve the data of one stroke
S4
S5
Is the stroke straight line?
No
Yes
S6
Define sub-pixels on a straight line as the basic portion of the character
S7
Define sub-pixels on a curved line as the basic portion of the character
Determine the color element level of a sub-pixel corresponding to the basic portion of a character
S8
Determine the color element levels of neighboring sub-pixels
S9
S10
Were all strokes contained in a character processed?
No
Yes
Convert the color element level of a sub-pixel to a luminance level
S11
Transfer luminance data indicating the luminance levels of the sub-pixels to a display device
S12
END

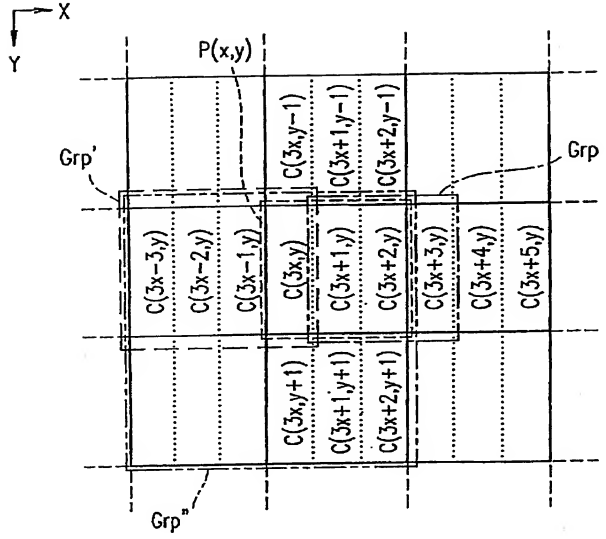
[Figure 13]


(a)
Sub-pixel 11
Pixel 10
(b)
Basic portion 12
14 13 13
13 13 14
0 1 2 5 7 5 2 1 0
Color element level
255 219 182 73 0 73 182 219 255
Luminance level

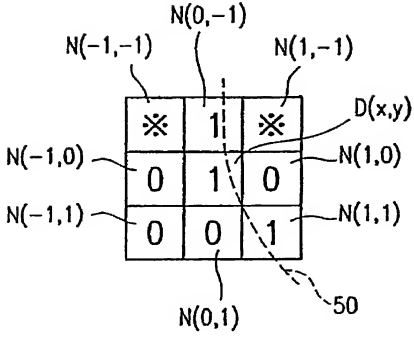
[Figure 15]



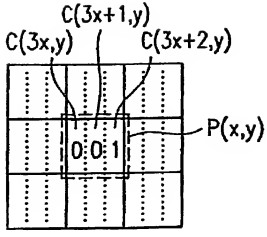
[Figure 16]


X
Y
P(x,y)
Grp'
Grp
Grp"
C(3x-3,y)
C(3x-2,y)
C(3x-1,y)
C(3x,y)
C(3x+1,y)
C(3x+2,y)
C(3x+3,y)
C(3x+4,y)
C(3x+5,y)
C(3x,y-1)
C(3x+1,y-1)
C(3x+2,y-1)
C(3x,y+1)
C(3x+1,y+1)
C(3x+2,y+1)

[Figure 17A]



[Figure 17B]



[Name of the Document] ABSTRACT

[Abstract]
[Problems] Characters with high resolution and definition are displayed by a simple process.

[Means for Solving the Problems] When a character of color is displayed on a display surface of a display device provided with a plurality of pixels each containing sub-pixels arranged in a predetermined direction and each assigned with RGB, a plurality of sub-pixels is associated with a basic portion representing a skeleton of a character, and an arrangement of sub-pixels is extracted from a sub-pixel contained in a pixel whose pixel value is to be determined and from its neighboring sub-pixels. The basic portion is associated with the arrangement of the sub-pixels. Luminance levels of sub-pixels are determined based on the extracted arrangement of the sub-pixels.

[Selected Figure] Figure 8

CERTIFICATE OF TRANSLATION

I, TAKESHI OSHIO, patent attorney of Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-ku, Osaka 540-6015, Japan HEREBY CERTIFY that I am acquainted with the English and Japanese languages and that the attached English translation is a true English translation of what it purports to be, a translation of Manuscript Reference No. 01J04534 prepared on September 28, 2001 and cover sheet thereof in the name of SHARP KABUSHIKI KAISHA.

Dated this 18th day of July 2007

Takeshi Oshio

TAKESHI OSHIO

(Translation)

Supplemented October 26, 2001

[1. Title of the Invention] CHARACTER DISPLAY APPARATUS AND CHARACTER DISPLAY METHOD, RECORDING MEDIUM AND PROGRAM

[2. Scope of the Claims]

[Claim 1] (Display information is determined with an arrangement pattern of sub-pixels)

A character display apparatus, comprising:

a display device including a plurality of pixels; and

a control section for controlling the display device, wherein

each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction,

the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process,

from a sub-pixel contained in a pixel whose pixel value is to be determined and its neighboring sub-pixels, the control section extracts an arrangement of sub-pixels corresponding to the basic portion, and

based on the extracted arrangement of sub-pixels, the control section determines luminance levels of the plurality of sub-pixels and displays a character on the display device.

[Claim 2](Character is easily avoided from being diminished with a table scheme)

A character display apparatus according to claim 1, characterized in that the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined to a correspondence between the arrangement of sub-pixels obtained by replacing the position of a sub-pixel corresponding to the basic portion with its neighboring

sub-pixels and the luminance levels of the sub-pixels to be determined, thereby making it possible to easily avoid a character from being diminished.

[Claim 3](Thickening of a line width of character is easily realized with a table scheme)
A character display apparatus according to claim 1, characterized in that the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined to a correspondence between the arrangement of sub-pixels and the luminance levels of the sub-pixels to be determined, thereby making it possible to easily change a line width of a character.

[Claim 4](Background color correspondence: Basic)
A character display apparatus according to claim 1, characterized in that the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined depending on a combination of a character color and a background color to be displayed.

[Claim 5](Background color correspondence: Expansion)
A character display apparatus according to claim 4, characterized in that the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined according to the size of the difference between character and background colors previously registered and character and background colors to be displayed.

[Claim 6] (Method)
A character display method for displaying a character on a display device including a plurality of pixels,
wherein

each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and

the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process,

the character display method comprising the step:

determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion.

[Claim 7] (Recording medium)

A recording medium readable by an information display apparatus including a display device including a plurality of pixels and a control section for controlling the display device,

wherein

each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and

the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process,

the recording medium having a program recorded thereon for causing the control section to execute a process including the step of:

determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion.

[Claim 8] (Program)

A program for causing an information display apparatus to execute a character display process, the information display apparatus including a display device including a plurality of pixels and a control section for controlling the display device,

wherein

each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and

the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process,

the program comprising the step of:

determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion.

[3. Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to: a character display apparatus capable of displaying characters with high resolution using a display device capable of displaying color; a character display method; a recording medium; and a program.

[0002]

[Prior Art]

As a display technique capable of displaying characters with high resolution using a display device capable of displaying color, Japanese Laid-Open Publication No. 2001-100725 discloses the following technique. According to this technique, a display surface of the display device includes a plurality of pixels each consisting of a group of sub-pixels including a plurality of color elements (e.g., Red (R), Green (G), and Blue (B)). The strength of each color element is represented by color element level. If a certain level of color element is assigned to a sub-pixel corresponding to the skeleton of a character, a predetermined pattern of color element levels which vary stepwise around the sub-pixel is set for its surrounding sub-pixels. Each

color element level is converted to a luminance level based on a predetermined correspondence. The level of a color element corresponds to the degree of the color element which contributes to the color of a character. Therefore, the greater the contribution of a sub-pixel to the color of a character, the greater the color element level of the sub-pixel. The greater the contribution of a sub-pixel to the color of a background, the lower the color element level of the sub-pixel. In addition, the luminance level of a sub-pixel corresponds to the degree of light emission of the sub-pixel. The greater the luminance level of a sub-pixel, the greater the degree of light emission of the sub-pixel. The lower the luminance level, the lower the degree of light emission. In this manner, the shapes of characters are represented on a sub-pixel-by-sub-pixel basis, and by forming a pattern of color element levels which vary stepwise, characters can be displayed with high resolution while color noise is suppressed. Further, Japanese Laid-Open Publication No. 2001-184051 discloses another technique capable of displaying characters with high resolution in any character color and any background color, by appropriately changing a predetermined correspondence when converting, in the conventional technique, the color element level to the luminance level according to the color of a character and the color of a background to be displayed.

[0003]

[Problems to be Solved by the Invention]

However, in the above-described conventional technique, a pattern of the color element levels of sub-pixels constituting the shape of a character is set, and thereafter, the color element levels are converted to respective luminance levels which are actually to be displayed on a display device. Therefore, the process is complicated and a working memory area required for performing the process is increased. As a result, there are problems that character

display processing is slowed, the hardware cost is increased, and the like.

In addition, when strokes of a character are close to each other, the conventional technique described above discloses a method for preventing the deformation of a character between the strokes by changing a pattern of color element levels. However, there is a problem that the process is made complicated in order to change a pattern of color element levels by actually recognizing the positional relationship between strokes.

Further, when arbitrary colors are set to characters and backgrounds to be displayed, in some combination of colors, a pattern of color element levels constituting the shape of a character is not suitable for representing the colors of the set character and background, thus causing a problem that the shape of the character is degraded and the visibility of the character is significantly reduced.

[Means for Solving the Problems]

In order to solve the first problem describe above, a character display apparatus according to the present invention includes: a display device including a plurality of pixels; and a control section for controlling the display device, wherein each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process, from a sub-pixel contained in a pixel whose pixel value is to be determined and its neighboring sub-pixels, the control section extracts an arrangement of sub-pixels corresponding to the basic portion, and based on the extracted arrangement of sub-pixels, the control section determines luminance levels of the plurality of sub-pixels and displays a character on the display device,

thereby the first problem described above is solved.

In order to solve the second problem describe above, in a character display apparatus according the present invention, the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined to a correspondence between the arrangement of sub-pixels obtained by replacing the position of a sub-pixel corresponding to the basic portion with its neighboring sub-pixels and the luminance levels of the sub-pixels to be determined, thereby making it possible to easily avoid a character from being diminished, thereby the second problem described above is solved.

In addition, the control section may change a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined to a correspondence between the arrangement of sub-pixels and the luminance levels of the sub-pixels to be determined. Therefore, a sub-pixel corresponding to a basic portion of a character is multiplexed, and as a result, the line width of the appearance of the character is thickened.

In order to solve the third problem described above, in a character display apparatus according to the present invention, the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined depending on a combination of a character color and a background color to be displayed, thereby the third problem described above is solved.

In addition, the control section changes a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined according to the size of the difference between character

and background colors previously registered and character and background colors to be displayed.

A character display method according to the present invention is provided for displaying a character on a display device including a plurality of pixels, wherein each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process, the character display method including the step: determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion, thereby the problem described above is solved.

A recording medium according to the present invention is provided, which is readable by an information display apparatus including a display device including a plurality of pixels and a control section for controlling the display device, wherein each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process, the recording medium having a program recorded thereon for causing the control section to execute a process including the step of: determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion, thereby the problem described above is solved.

A program is provided for causing an information display apparatus to execute a character display process, the

information display apparatus including a display device including a plurality of pixels and a control section for controlling the display device, wherein each of the plurality of pixels includes a plurality of sub-pixels arranged in a predetermined direction, and the plurality of sub-pixels is associated with a basic portion representing a skeleton of a character by a predetermined process, the program including the step of: determining luminance levels of the plurality of sub-pixels, based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion, thereby the problem described above is solved.

The functions of the present invention will be described hereinafter.

According to the present invention, a character is displayed on a display device having a plurality of pixels. In this case, each of the plurality of pixels includes a plurality of sub-pixels which is arranged in a predetermined direction. The plurality of sub-pixels is associated with a basic portion representing the skeleton of a character by a predetermined process. The luminance levels of the plurality of sub-pixels are determined based on a pixel whose pixel value is to be determined and an arrangement of its neighboring sub-pixels corresponding to the basic portion. Thereafter, the character is displayed on the display device. Therefore, when a character is displayed with high resolution and high definition, processes can be simplified and the processes can be performed at practical speed even using a CPU having a low processing speed. Further, the size of a program describing a procedure can be reduced, thereby making it possible to reduce the size of a memory apparatus. Furthermore, the simplification of processes can reduce a working memory region required during processing. As a result, the cost of a character display apparatus can be

reduced, thereby making it possible to realize a character display with high resolution and high definition.

In addition, according to the present invention, when the luminance levels of the plurality of sub-pixels are determined based on the arrangement of the sub-pixels corresponding to a basic portion, a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined is changed to a correspondence between the arrangement of sub-pixels obtained by replacing the position of a sub-pixel corresponding to a basic portion with its neighboring sub-pixels and the luminance levels of the sub-pixels to be determined. Therefore, when sub-pixels corresponding to the skeleton of a character are close to each other, the arrangement of sub-pixels can be changed so that such sub-pixels are spaced further apart. Thereby, it is possible to prevent a space between strokes of the character from being diminished, which deforms the character when strokes of the character are close to each other. The arrangement of sub-pixels corresponding to the skeleton of a character may not be suitable for the representation of the character, depending on a color combination of a character and a background. Even in this situation, by changing the arrangement of sub-pixels corresponding to the skeleton, distortion of the character can be corrected.

Further, according to the present invention, when the luminance levels of the plurality of sub-pixels are determined based on the arrangement of the sub-pixels corresponding to the basic portion, a correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixel to be determined is changed to a correspondence between the arrangement of sub-pixels obtained by providing a duplicate of a sub-pixel corresponding to the basic portion to its neighboring

sub-pixels and the luminance levels of the sub-pixels to be determined. Thus, when the luminance levels of the sub-pixels are determined, a sub-pixel corresponding to the skeleton of a character can be multiplexed, thereby making it possible to simplify a process of thickening the line width of a character so that the process can be efficiently performed.

Further, according to the present invention, when the luminance levels of the plurality of sub-pixels are determined based on the arrangement of the sub-pixel corresponding to the basic portion, the correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined can be changed depending on a combination of a character color and a background color to be displayed. Therefore, the optimum luminance levels of sub-pixels can be set depending on a character color and a background color. Therefore, characters having an optimum line width can be displayed for each color combination, whereby characters can be displayed with a high level of visibility irrespective of the color combination.

Further, according to the present invention, the correspondence between the arrangement of the sub-pixels and the luminance levels of the sub-pixels to be determined can be changed according to the size of the difference between character and background colors previously registered and character and background colors to be displayed. Therefore, the above-described correspondence can be shared by a group of characters having similar color combinations (similar luminance levels of sub-pixels), whereby characters can be displayed with a greater variety of color combinations and an optimum line width while suppressing the storage capacity of a character display apparatus to a low level.

[Embodiment of the Invention]

Figure 1 shows a representative configuration of a character display apparatus according to a conventional technique (Japanese Laid-Open Publication No. 2001-100725, Japanese Laid-Open Publication No. 2001-184051). The character display apparatus **1a** includes a display device **3** capable of displaying color and a control section **20**, which separately controls a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. The control section **20** includes a CPU **2** and a main memory **4**. The display device **3**, an input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**. The auxiliary memory apparatus **40** stores a display program **41a** for displaying characters and data **5**. The data **5** includes character shape data **5b**, correction pattern data **5c** and a luminance table **5d**. Examples of the character shape data **5b** include outline data representing the contour shapes of characters and skeleton data representing the skeletal shapes of characters. Note that characters to be displayed may include simple graphics, such as pictographic characters and the like. In descriptions below, characters are illustrated. The character shape data **5b** also includes bitmap data representing characters. Note that processing by the display program **41b** varies slightly depending on the type of the character shape data **5b**.

Figure **4** shows a process flow of the display program **41a** when the character shape data **5b** is skeleton data. The processes of the character display according to the present invention will be described with reference to the flow of Figure **4**.

Step S1: A character code and a character size are input from the input device **7**.

Step S2: Skeleton data of a character corresponding to the input character code is read from the auxiliary memory

apparatus **40** and stored in the main memory **4**.

Step S3: Coordinate data of each stroke contained in the skeleton data is scaled according to the input character size.

Step S4: The coordinate data contained in one stroke is retrieved.

Step S5: The type of the stroke is determined based on data contained in the skeleton data. If the stroke is a straight line, the process goes to step S6. If the stroke is not a straight line (curved line), the process goes to step S7.

Step S6: Sub-pixels on the straight line represented by the coordinate data of the stroke are defined as a basic portion representing the skeleton of the character.

Step S7: Sub-pixels on the curved line represented by the coordinate data of the stroke are defined as a basic portion representing the skeleton of the character.

Step S8: The color element levels of the sub-pixels corresponding to the basic portion of the character, defined in steps S6 and S7, are set to be the greatest color element levels (e.g., "7").

Step S10: It is determined whether all the strokes included in the character are processed. If "Yes", the process goes to step S11. If "No", the process returns to step S3 and is repeated.

Step S11: A luminance table representing a correspondence between the color element levels and the luminance levels is used so as to convert the set color element levels of the sub-pixels to respective luminance levels.

Step S12: Luminance data indicating the luminance levels of the sub-pixels set in step S11 is transferred to the display device.

In this manner, the luminance levels are adjusted on a sub-pixel-by-sub-pixel basis to display a character.

Herein, the description has been made regarding sub-pixels corresponding to a basic portion representing

the skeleton of a character being derived from skeleton data. Alternatively, such sub-pixels may be derived from bitmap data by a predetermined process. Alternatively, the pattern of the basic portion which is previously stored as data in a memory apparatus may be read and used.

Figure 2 shows an exemplary configuration of a character display apparatus according to the present invention. The character display apparatus **1b** may be, for example, a personal computer. Examples of the personal computer include any type of computer, such as desktop, laptop, and the like. Alternatively, the character display apparatus **1b** may be a word processor. Further, the character display apparatus **1b** may be any information display apparatus including a display device capable of displaying color, such as an electronic apparatus, an information apparatus. Examples of the character display apparatus **1b** also include electronic apparatuses including a color liquid crystal display device, and communication apparatuses (e.g., personal digital assistants, mobile telephones including PHS, general fixed telephones, FAX, etc.).

Similar to the conventional technique, the character display apparatus **1b** includes a display device **3** capable of displaying color and a control section **20**, which separately controls a plurality of color elements corresponding to a plurality of sub-pixels included in the display device **3**. The control section **20** includes a CPU **2** and a main memory **4**. The display device **3**, an input device **7** and an auxiliary memory apparatus **40** are connected to the control section **20**. The auxiliary memory apparatus **40** stores a display program **41b** for displaying characters and data **5**. The data **5** includes character shape data **5b** and a pixel value table **5e**. The pixel value table **5e** will be described later.

Herein, the display device 3, which is a basis for explaining the present invention, will be described.

Portion **(a)** of Figure 3 schematically shows a portion of the display surface of the display device. The display surface includes a plurality of pixels representing characters or graphics to be displayed. Each pixel consists of sub-pixels including a plurality of color elements (e.g., Red (R), Green (G), and Blue (B)).

Portion **(b)** of Figure 3 is a diagram for explaining use of sub-pixels for a basic portion of the skeleton of a character and an arrangement of a correction pattern for the basic portion. When the hatched sub-pixel corresponds to a basic portion, the color element level of the basic portion is set to be, for example, the greatest color element level of 7. The color element levels of the sub-pixels neighboring the sub-pixel corresponding to the basic portion are set to be 5, 2 and 1 from the nearest to the basic portion, based on a correction table **2060** shown in Figure **11** when a correction pattern 1 is selected. The color pixel levels of sub-pixels corresponding to the background are set to be 0. The color element levels are converted to the luminance levels based on a correspondence between the color element levels and the luminance levels shown in a luminance table shown in Figure **12**. In the example shown in Portion **(b)** of Figure 3, from the left-hand side of the table, the sub-pixel having the color element level 0 of R is set, according to the luminance table, to have the luminance level "255", the sub-pixel having the color element level 1 of G is set to have the luminance level "219", and the sub-pixel having the color element level 2 of B is set to have the luminance level "182". Similarly, the sub-pixels having the color element levels (5, 7, 5) is set to have the luminance levels (73, 0, 73), and the sub-pixels having the color element levels (2, 1, 0) is set to have the luminance levels

(182, 219, 255). When correction patterns, corresponding to neighboring basic portions, overlap each other, the color element level having the largest value is set. A pattern of a basic portion representing the skeleton of an actual character of Kanji character "忙" is shown in Figure 13 as an example. The sub-pixels in black in the figure correspond to basic portions.

It is assumed that N correction patterns are set in this manner. In the character display method according to the present invention, as shown in Portion (c) of Figure 3, when the luminance levels of M sub-pixels contained in the pixel of interest are determined, it is possible to determine the luminance levels of the sub-pixels contained in the pixel of interest (i.e., pixel value of the pixel), by checking the arrangement pattern of a basic portion included in M+2×N sub-pixels including N neighboring sub-pixels which neighbor each side of the pixel of interest.

Figure 5 shows a process flow of character display according to the present invention. The flow of the character display will be described with reference to the process flow.

Step S1: A character code and a character size are input from the input device 7.

Step S2: Skeleton data of a character corresponding to the input character code is read from the auxiliary memory apparatus 40 and stored in the main memory 4.

Step S3: Coordinate data of each stroke contained in the skeleton data is scaled according to the input character size.

Step S4: The coordinate data contained in one stroke is retrieved.

Step S5: The type of the stroke is determined based on data contained in the skeleton data. If the stroke is a straight line, the process goes to step S6. If the stroke is not

a straight line (curved line), the process goes to step S7.
Step S6: Sub-pixels on the straight line represented by the coordinate data of the stroke are defined as a basic portion representing the skeleton of the character.
Step S7: Sub-pixels on the curved line represented by the coordinate data of the stroke are defined as a basic portion representing the skeleton of the character.
Step S10: It is determined whether all the strokes included in the character are processed. If "Yes", the process goes to step S101. If "No", the process returns to step S3 and is repeated.
Step S101: An arrangement pattern for a basic portion included in the sub-pixels which neighbor the pixel, whose pixel value is to be determined, is checked.
Step S102: The pixel value table **5e** is searched, and the luminance levels of the sub-pixels corresponding to the arrangement pattern for the basic portion, which is checked in Step S101, are set for the pixel, whose pixel value is to be determined.
Step S12: Luminance data indicating the luminance levels of the sub-pixels set in step S102 is transferred to the display device.

As described above, the pixel values of pixels can be set collectively based on an arrangement of sub-pixels corresponding to a basic portion.

Figure **6** shows an example of a correspondence between an arrangement of sub-pixels for a basic portion and a pixel value (R, G, B luminance value) of a pixel contained in the pixel value table **5e** in the configuration shown in Figure **2**.

The table at the left-hand side of Figure **6** shows a pattern of 9 sub-pixels corresponding to 3 pixels which are arranged in the same direction as that of the arrangement

of the sub-pixels. In the table, element "0" indicates that a basic portion is not assigned to a sub-pixel relating to the element; element "1" indicates that a basic portion is assigned to a sub-pixel relating to the element; and element "x" indicates that either a basic portion is assigned to a sub-pixel relating to the element or a basic portion is not assigned to a sub-pixel relating to the element. In addition, the table at the right-hand side of Figure 6 shows the luminance value of each sub-pixel (R, G, B) contained in a pixel corresponding to the pattern on the left-hand side of Figure 6, as elements in the table. The pixel value of a pixel is determined using the table indicating a correspondence between the arrangement of sub-pixels corresponding to the basic portion of a character and the luminance values of sub-pixels contained in a pixel whose pixel value is to be determined. The examples shown in Figure 6 and later to be described show a case in which the number of sub-pixels shown in Portion (c) of Figure 3 is M=N=3. For example, in the case in which the arrangement of sub-pixels corresponding to a basic portion is "x10 000 01x", the arrangement of the color element levels is "x75, 212, 57x" according to the correction pattern. The color element levels (2, 1, 2) of sub-pixels (R, G, B) contained in a pixel whose pixel value is to be set are converted to luminance levels (182, 219, 182) according to the correspondence in the luminance table. Therefore, in the table of Figure 6, the arrangement "x10 000 01x" of the sub-pixels and the luminance levels (182, 219, 182) make up a pair of elements. Also, a correspondence is set for other elements in the table in a similar manner.

Figure 7 shows another example of a correspondence between an arrangement of sub-pixels for a basic portion and a pixel value of a pixel (R, G, B luminance value).

Similar to Figure 6, Figure 7 shows the luminance levels

of sub-pixels contained in a pixel, which correspond to the arrangement of the sub-pixels shown at the left-hand side of the table. For example, in the case in which the arrangement of sub-pixels is "000 001 000", the arrangement of the color element levels is "001, 257, 521" according to the correction pattern. The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel whose pixel value is to be set are converted to luminance levels (182, 73, 0) according to the correspondence in the luminance table. Therefore, in the table of Figure 7, the arrangement "000 001 000" of the sub-pixels and the luminance levels (182, 73, 0) make up a pair of elements.

As described above, the correspondence between the arrangement for a basic portion and the luminance values of the sub-pixels is tabulated. Therefore, when sub-pixels corresponding to a basic portion are close to each other, the pixel values of pixels present between strokes of a character can be controlled by particularly adjusting the luminance values of sub-pixels corresponding to the arrangement. Therefore, it is possible to prevent black pixels from filling between strokes of a character, i.e., a space within the character is diminished, or the like. Thus, the quality of display can be improved.

Figure 8 shows an example of a correspondence between an arrangement of sub-pixels for a basic portion and a pixel value of a pixel (R, G, B luminance value) including the shift of the basic portion.

The arrangement of sub-pixels at the left-hand side of Figure 8 shows a similar case to the one shown in Figure 7. As an example of a correspondence including the shift of the basic portion, in the table in the middle of Figure 8, sub-pixels corresponding to a basic portion are replaced with the sub-pixels located at the middle of three sub-pixels

contained in each pixel. The correspondence shown in Figure 8 is represented by the relationship between the original arrangement of the sub-pixels (at the left-hand side of Figure 8) and the pixel value of the pixel which is determined (at the right-hand side of Figure 8) based on the arrangement after the replacement of the basic portion included in the original arrangement.

For example, when the arrangement of sub-pixels is "000 001 000", the arrangement of the sub-pixels is changed to "000 010 000" by replacement of the basic portion. Due to this, the arrangement of the color element levels is "012, 575, 210" according to the correction pattern, and the color element levels (5, 7, 5) of sub-pixels (R, G, B) contained in a pixel whose pixel value is to be set are converted to luminance levels (73, 0, 73) according to the correspondence in the luminance table. Therefore, in the table of Figure 8, the arrangement "000 001 000" of the sub-pixels and the luminance levels (73, 0, 73) make up a pair of elements.

Figure 9 shows an example of a correspondence between an arrangement of sub-pixels for a basic portion and a pixel value of a pixel (R, G, B luminance value) including the multiplexing of the basic portion.

The table of the middle of Figure 9 shows an arrangement in which a basic portion is duplicated (multiplexed) at the left-hand side of the arrangement of the sub-pixels in the table at the left-hand side of Figure 9. The pixel value of a pixel to be determined based on the arrangement of the sub-pixels including the multiplexed basic portion is shown in the table at the right-hand side of Figure 9. The correspondence between the arrangement of these sub-pixels and the pixel value of the pixel is used for the pixel value table 5e shown in Figure 2. For example, when the arrangement of sub-pixels is "x10 000 01x x", the arrangement of the

sub-pixels is changed to "x10 000 11x x" by providing a duplicate of the basic portion to the left-hand side of the sub-pixel. Due to this, the arrangement of the color element levels is "x75, 225, 77x, x" according to the correction pattern. The color element levels (2, 2, 5) of sub-pixels (R, G, B) contained in a pixel whose pixel value is to be set are converted to luminance levels (182, 182, 73) according to the correspondence in the luminance table. Therefore, in the table of Figure **9**, the arrangement "x10 000 01x x" of the sub-pixels and the luminance levels (182, 182, 73) make up a pair of elements.

Figure **10** is an example of a correspondence between an arrangement of sub-pixels for a basic portion and a pixel value of a pixel (R, G, B luminance value) when orange (R, G, B = 255, 127, 0) is used as a background color.

In Figure **10**, when the arrangement of sub-pixels is "000 000 000", there is no sub-pixel corresponding to the basic portion of a character. A pixel whose pixel value is to be set corresponds to a background. Therefore, the luminance values of (R, G, B) are (255, 127, 0). A correction pattern, which is stepwise changed, is adjusted according to the distribution of luminance in the background color. For example, in the case in which the arrangement of sub-pixels is "000 001 000", when the background color is white, the arrangement of color element levels is "001,257,521" as shown in the example in Figure **7**. The color element levels (2, 5, 7) of sub-pixels (R, G, B) contained in a pixel whose pixel value is to be set are set to luminance levels (182, 73, 0). In contrast, when the background color is orange, the ratio of the luminance levels (R, G, B) is (1, 1/2, 0). Therefore, the color element levels (2, 5, 7) of the sub-pixels (R, G, B) contained in the pixel whose pixel value is to be set are adjusted to luminance levels (182, 36, 0) where the level of G becomes $73 \times 1/2 \cong 36$. Thus,

when the background color is orange, in the table of Figure **10**, the arrangement "000 001 000" of the sub-pixels and the adjusted luminance levels (182, 36, 0) make up a pair of elements.

A correspondence between an arrangement of sub-pixels and a pixel value to be set for arbitrary character color and background color is derived, for each color combination, from a table, for example, as shown in Figure **10**. The correspondence can be adjusted according to the character color and background color based on the table (e.g., the one shown in Figure **6** or Figure **7**) indicating a correspondence for a basic color combination, i.e., black characters in a white background. Alternatively, instead of adjusting the table as described above, a table may be provided for each combination of a character color and a background color. Further, when there are a number of combinations of a character color and a background color, similar colors may be grouped and tables indicating a correspondence are provided for respective representative colors according to the size of a difference between the character and background colors and the representative color. For example, the sum of squares of differences between each color element (R, G, B), the sum of absolute differences between each color element (R, G, B), or the like, can be used as an indicator for determining the size of a color difference. A difference in color element level in color space (e.g., YUV space, Lab space, or the like) according to visual characteristics may be used as an indicator for determining a color difference. If a difference between a representative color assigned to the table indicating the correspondence and a color specified in displaying a character is less than or equal to a predetermined threshold, the specified color is determined as a color belonging to a group including the representative color and the table indicating the correspondence can be used to determine the pixel value to be set.

The above-described pixel value table **5e** indicating a correspondence between the arrangement of sub-pixels and the pixel value of a pixel has $2^{(M+2\times N)}$ entries of arrangement combinations of sub-pixels, i.e., the combinations of the presence or absence ("1" or "0") of a basic portion for (M+2×N) sub-pixels. For example, in the example of M=N=3, the number of entries is 512. However, in the number of combinations of corresponding pixel values, correction patterns are set so as to be stepwise changed. Therefore, the sequence of the luminance values of sub-pixels is limited. In addition, when correction patterns overlap in a sub-pixel, the larger color element level is set in the sub-pixel. Therefore, the number of pixel values obtained by combinations of sub-pixels is

(Expression 1)

$$(N+3)^2-\left(\sum_{n=1}^{N} n+1\right)\times 2+1 = 5\times N+8$$

Therefore, in the example of M=N=3, the number of pixel values is 23. By assigning 23 indexes to 512 patterns, a data capacity required for storing pixel values actually set can be reduced as compared to when a total of 24-bit full color data is prepared in a table where each of (R, G, B) has a length of 8 bit (=0 to 255), for example.

In the description regarding a correspondence between the arrangement of sub-pixels and the pixel value of a pixel, the sub-pixel of interest is arranged in a direction along which, for example, R, G, and B are arranged. However, the present invention is not so limited. Alternatively, a similar correspondence can be used for other arrangements, for example in the case in which the sub-pixel of interest is arranged in a direction perpendicular to which, for

[Effect of the Invention]

As described above, according to the present invention, when a character is displayed with high resolution using sub-pixels on a display device capable of displaying color, a luminance level to be displayed on the display device can be obtained directly by converting the arrangement of sub-pixels constituting the shape of a character. Therefore, the character display process can be performed at a higher rate and a working memory area for performing the character display process can be reduced. As a result, the present invention can obtain an effect that character display processing can be performed at the same or higher rate and the hardware cost can be reduced.

In addition, when character strokes are close to each other, the present invention can obtain an effect that a pattern of color element levels can be easily set to prevent deformation of a character, i.e., by preventing filling of a space between the strokes.

Further, in the case in which arbitrary color is set to a character and a background to be displayed, the present invention can obtain an effect that the shape of a character is retained and a high level of visibility is achieved irrespective of a color combination since a pattern of color element levels constituting the shape of a character is appropriately set in order to represent a character color and a background color.

Further, in a correspondence between the arrangement of sub-pixels and the pixel value, similar combinations of a character color and a background color may be grouped for arbitrary combination of characters and backgrounds so as to be merged into a correspondence table for a representative color combination. Therefore, the present invention can obtain an effect that a data amount required for the table

indicating the correspondence can be reduced.

[4. Brief Description of the Drawings]

[Figure 1]

Figure 1 is a diagram showing a configuration of a character display apparatus according to a conventional technique.

[Figure 2]

Figure 2 is a diagram showing a configuration of a character display apparatus according to the present invention.

[Figure 3]

Figure 3 is a diagram for explaining a sub-pixel configuration and a correction pattern.

[Figure 4]

Figure 4 is a diagram showing a process flow of the character display apparatus according to the conventional technique.

[Figure 5]

Figure 5 is a diagram showing a process flow of the character display apparatus according to the present invention.

[Figure 6]

Figure 6 is a diagram showing an example of a correspondence between an arrangement of sub-pixels and a pixel value of a pixel.

[Figure 7]

Figure 7 is a diagram showing another example of a correspondence between an arrangement of sub-pixels and a pixel value of a pixel.

[Figure 8]

Figure 8 is a diagram showing another example of a correspondence between an arrangement of sub-pixels and a

pixel value of a pixel.

[Figure 9]
Figure **9** is a diagram showing another example of a correspondence between an arrangement of sub-pixels and a pixel value of a pixel.

[Figure 10]
Figure **10** is a diagram showing another example of a correspondence between an arrangement of sub-pixels and a pixel value of a pixel.

[Figure 11]
Figure **11** is a diagram showing an exemplary correction table stored in the correction pattern data **5c**.

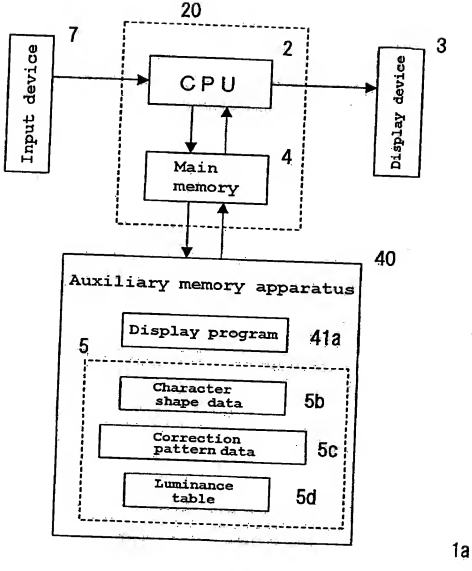
[Figure 12]
Figure **12** is a diagram showing an example of the luminance table **5d**.

[Figure 13]
Figure **13** is a diagram showing an exemplary pattern of sub-pixels corresponding to a basic portion in a Kanji character "忙".

[Description of the Reference Numerals]
1a, 1b character display apparatus
2 CPU
20 control section
3 display device
4 main memory
40 auxiliary memory apparatus
41a, 41b display program
5 data
5b character shape data
5c correction pattern table

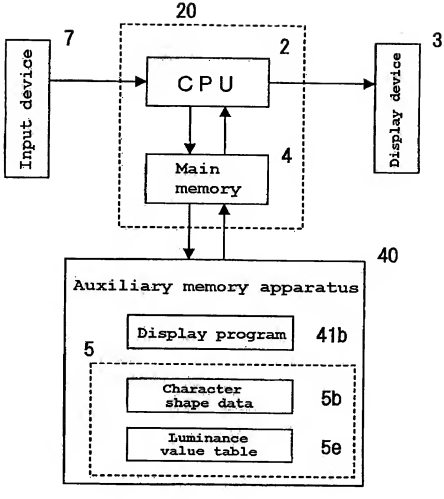
5d luminance table
5e pixel value table
7 input device

[Figure 1]



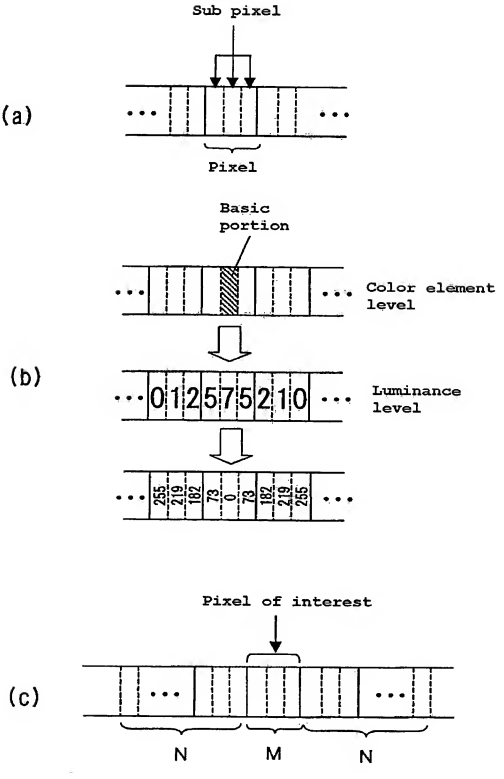
Configuration of a character display apparatus according to a conventional technique

[Figure 2]



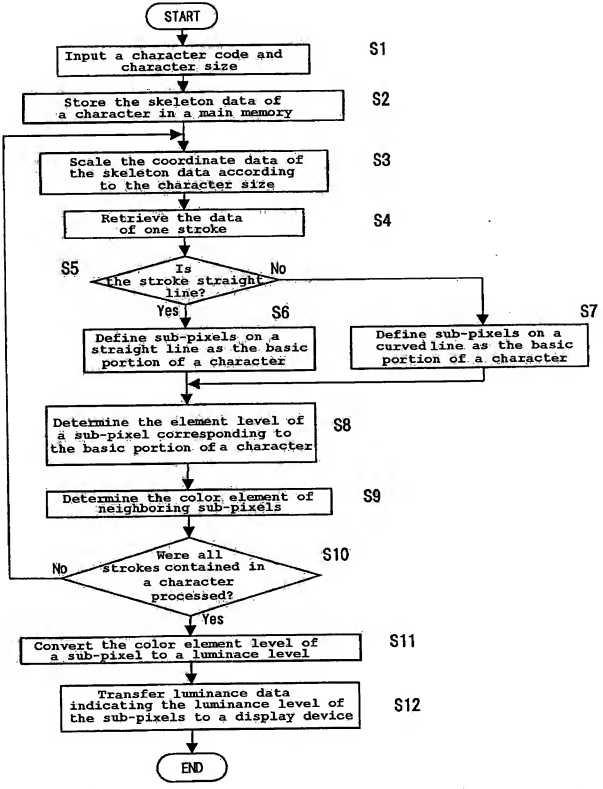
Configuration of a character display apparatus according to the present invention

[Figure 3]



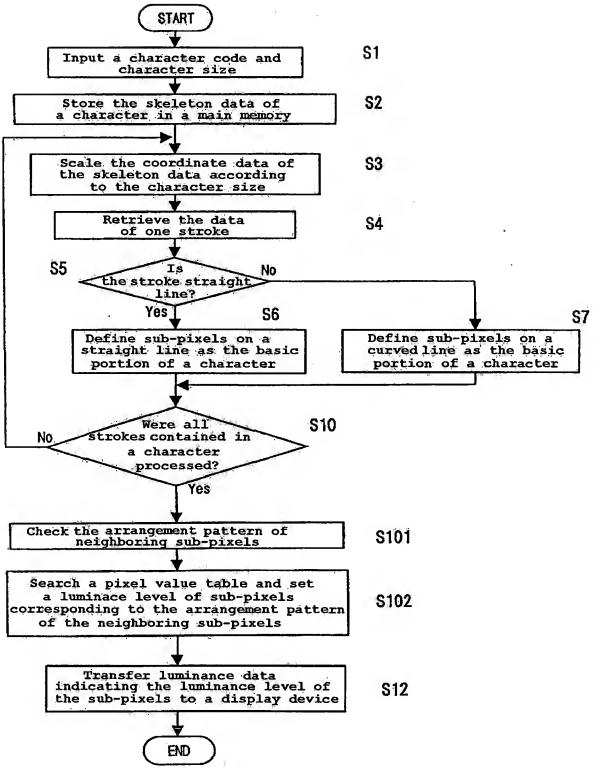
Explanation of sub-pixel configuration and correction pattern

[Figure 4]



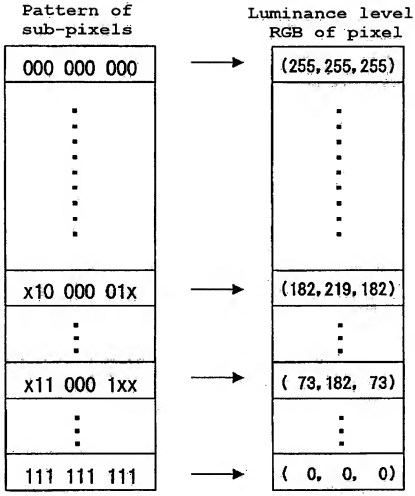
Process flow according to the conventional technique

[Figure 5]



Process flow according to the present invention

[Figure 6]

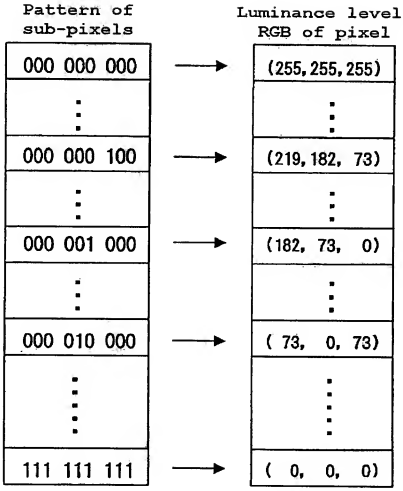


Example of N=M=3

Example (1) of correspondence (table) of arrangement of sub-pixels and pixel value of pixel

Corresponds to Claim 1

[Figure 7]



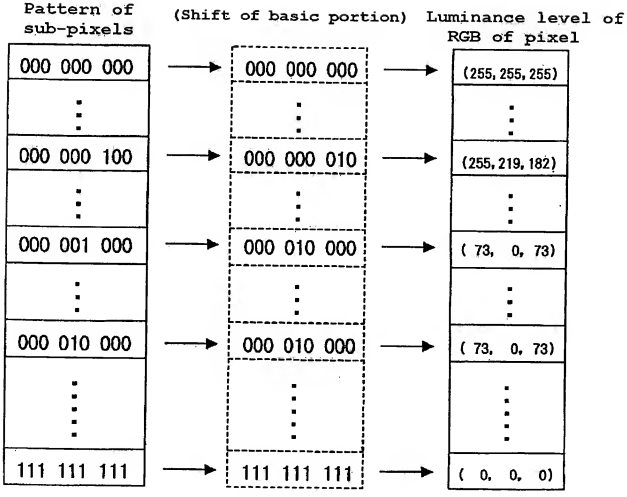
When there is no shift of basic portion

Example of N=M=3

Example (2) of correspondence (table) of arrangement of sub-pixels and pixel value of pixel

Corresponds to Claim 1

[Figure 8]

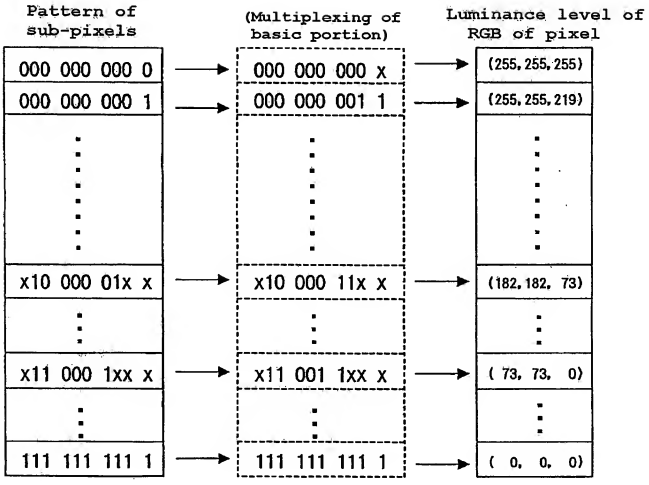


Example of N=M=3

Example (3) of correspondence (table) of arrangement of sub-pixels and pixel value of pixel

Corresponds to Claim 2

[Figure 9]

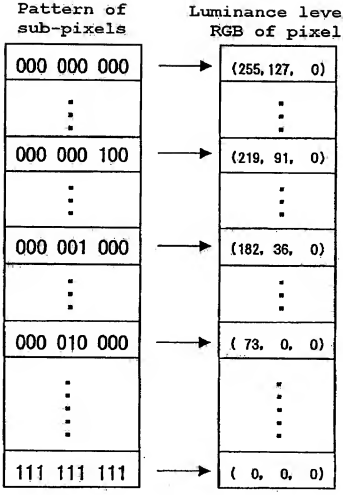


Example of N=M=3

Example (4) of correspondence (table) of arrangement of sub-pixels and pixel value of pixel

Corresponds to Claim 3

[Figure 10]



When background color is orange (255, 127, 0)

Example of N=M=3

Example (5) of correspondence (table) of arrangement of sub-pixels and pixel value of pixel

Corresponds to Claim 4

[Figure 11]

Correction table 2060

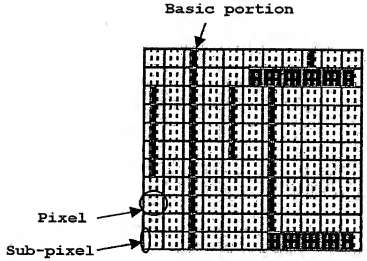
		Correction pattern 1	Correction pattern 2
Color element level	Sub-pixel 1	5	4
	Sub-pixel 2	2	2
	Sub-pixel 3	1	1

[Figure 12]

Luminance table 2070

Color element level	Luminance level R	Luminance level G	Luminance level B
7	0	0	0
6	36	36	36
5	73	73	73
4	109	109	109
3	146	146	146
2	182	182	182
1	219	219	219
0	255	255	255

[Figure 13]



Example of basic portion pattern
for Kanji character "忙"